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A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING.

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THE EFFECTS OF A CONTROLLED THERMAL ENVIRONMENT ON PUPIL LEARNING WERE ANALYZED. APPROXIMATELY 20 MATCHED PAIRS OF FIFTH-GRADE STUDENTS WERE SELECTED. TWO GROUPS WERE USED--ONE FOR AN IDEAL THERMAL ENVIRONMENT AND THE OTHER FOR A DEVIATE THERMAL ENVIRONMENT. THE STUDENTS WERE MATCHED BY INTELLIGENCE TEST SCORES, ACHIEVEMENT TEST RESULTS, SEX, AGE, AND FAMILY BACKGROUND. THE CLASSROOMS WERE IDENTICAL IN ALL PHYSICAL ASPECTS. TEACHING INSTRUCTION FOR BOTH GROUPS WAS IDENTICAL, AND A WEEKLY ACHIEVEMENT SCORE WAS COLLECTED FROM ALL PARTICIPATING STUDENTS. THE STUDY LASTED ALMOST NINE SCHOOL WEEKS. RESULTING DATA WAS STATISTICALLY ANALYZED USING VARIANCE PROCEDURES. THE CONCLUSION REACHED BY THIS STUDY WAS THAT STUDENT LEARNING IS NOT AFFECTED BY ATTENDING SCHOOL IN A CONTROLLED IDEAL THERMAL ENVIRONMENT. (JH)

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A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING

Cooperative Research Project No. 5-8368-2-12-1

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University of Iowa
Iowa City, Iowa

1966

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A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING

by

Burdette P. Hansen

A dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of
Philosophy in the College of Education
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February 1966

Chairman: Professor Willard R. Lane

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CHAPTER I

THE PROBLEM

The purpose of this chapter is to (1) explain the objective of the study, (2) state the problem, both in general terms and more specifically in a null hypothesis, (3) establish a need for the study, (4) state the purpose of the study, and (5) to define the terms used throughout the study.

Objective

This study was concerned with analyzing the effects of a controlled thermal environment on pupil learning.

The research was specifically designed to determine if pupils attending school in a controlled model thermal environment attained statistically significant greater learning than did pupils attending school in a controlled non-model thermal environment. This study was designed in such a way as to ensure that other factors affecting pupil learning would be controlled. In this manner, it was possible to definitely determine the educational benefits achieved by a controlled model thermal environment.

Statement of Problem

The professional literature abounds with statements about the educational value of thermal controlled environment in the classroom. A very positive statement concerning the value of a thermal environment was made by Frye: "In fact, educators have known for several decades there is a close correlation between comfort and learning."[1] A strong case was made for school air conditioning by Mark Hampton, architect, from Tampa, Florida. Hampton states, "The whole reason for air conditioning is that the child in the classroom will be better able to concentrate, and the teachers will be better able to teach."[2]

However, the National Council on Schoolhouse Construction in their 1965 Guide for Planning School Plants did not make as conclusive a statement concerning the value of a controlled thermal environment:

> Research has not established a definite relationship between learning and various thermal conditions, but many authorities imply

---

[1] R. A. Frye, "See More - Hear More - Learn More in Windowless Rooms," Education Screen and Audio-Visual Guide, 40, 274-7.

[2] Henry Wright, "Architects Consensus: Air Conditioning, Yes, Windowless School "No," Nation Schools, 74:62-3, October 1964.

that one exists.[3]

The problem examined in this study was to compare students' learning achievement in a controlled model thermal environment with students' learning achievement in a controlled non-model thermal environment. For the sake of clarity the controlled model thermal classroom has been referred to as the ideal thermal environment; the controlled non-model thermal classroom is termed the deviate thermal environment.

To be more specific, the following hypothesis was tested in this study:

H: There is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment.

Need For the Study

Education is now of national concern. National legislation of the past few years can be used to point out the nation's growing concern for providing better educational opportunities in this country. This nation, through various programs, is attempting to improve the education of its citizens.

---

[3] National Council on Schoolhouse Construction, Guide For Planning School Plants, AASA, 1965, p. 112.

One way to improve the present education program is by increasing the learning efficiency of all students. It seems clear that if a method of increasing students' learning efficiency can be found, it would be to this country's interests.

It is the purpose of this study to statistically measure whether children learn more efficiently in an environment that is considered ideal, than in a deviate environment. It was believed that this study, the third in a series of such studies conducted at the State University of Iowa, would permit generalizations about the learning of pupils in an ideal thermal environment as opposed to learning in a deviate environment.

This country has the industrial knowledge to construct classrooms with controllable thermal environments. Each year more and more school buildings are constructed with a controllable thermal environment. As far back as 1961 the following statement appeared in the October issue of Overview: "Almost three new educational buildings are being completed every day with full or partial air-conditioning."[4]

---

[4] _____, "Air Conditioning and the Learning Environment," Overview, 2:50-3, October 1961.

Not all school buildings presently being constructed include provisions for a controlled thermal environment. Obstacles remain in the way before a controlled thermal environment will be provided in every newly constructed school building:

> Two major obstacles still seem to stand in the way of the universal provision of school air-conditioning. First, neither all educators nor all architects have fully accepted the availability and financial practicality of systems controlling high temperature and humidity. Second, boards of education, trustees, and lay citizens are still not fully aware that air-conditioning brings actual increases in building use and educational effectiveness.[5]

It was not the purpose of this study to research the cost of providing a controlled thermal classroom environment. However, since cost is one of the major obstacles retarding the providing of a controlled classroom thermal environment, it is examined briefly.

The experience of the Omaha Public Schools in constructing air-conditioned classrooms is reported in Table I.

Manning wrote: "In answer to the original query regarding feasibility of school air conditioning, the team concluded: air conditioning can be installed in schools for little additional cost over heating alone, providing the

---

[5] Ibid.

TABLE I
COMPARATIVE COSTS OF AIR-CONDITIONED AND CONVENTIONAL JUNIOR HIGH SCHOOLS OMAHA, NEBRASKA[3]

Bid Date	Air Cond.	Student Cap.	Total[1] Cost	Total Sq. Ft.	Cost per Sq. Ft.	Cost per pupil
Jan-57	No	1350	2,179,580	142,000	15.35	1,614.00
Oct-57	No	1350	2,231,819	152,800	14.60	1,653.00
Sep-62[2]	No	1200	1,971,957	128,720	15.32	1,643.00
Sep-63	Yes	1200	2,079,747	132,780	15.66	1,733.00
Oct-63	Yes	1200	1,960,613	138,830	14.12	1,634.00
Feb-64	Yes	1200	1,927,540	138,830	13.88	1,606.00

---

[1] Exclusive of site costs and site development

[2] Does not have swimming pool, all others do

[3] Records of the Omaha Public Schools.

school is designed for it."[6]

Therefore, it does appear that some evidence has been compiled to overcome the cost obstacle of providing a controlled classroom thermal environment. However, very limited research evidence has been collected to overcome the second obstacle.

Purpose of the Study

Does providing an ideal controlled thermal environment in the classroom increase students' achievement? It is felt this research collected evidence which will help to answer that question.

The Textile Industry reported:

> The textile people found that when you create good temperature and lighting conditions, and control humidity in textile mills, not only do people perform better and produce more, they also produce a higher quality of product.[7]

Studies involving control and experimental groups with varied thermal environments, with the exception of University of Iowa studies, do not exist. Other areas of the public sector have studied the benefits of having their employees work in a controlled thermal environment:

---

[6] William R. Manning and Lionel R. Olsen, "Air Conditioning: Keystone of Optimal Thermal Environment," American School Board Journal, 149:22-23, August 1964.

[7] _____, Nation School, 74:62-3, op. cit.

> In 1957, however, a five-month study conducted by the Office of Buildings Management, General Services Administration, indicated workers in air conditioned spaces have a 9.5 percent greater output than do workers in similar spaces without air conditioning. The study also revealed that there is a 2.5 percent less absenteeism among workers in air conditioned spaces.[8]

It was the purpose of this study to find out if similar greater output might occur among students if they were educated in a controlled ideal thermal classroom environment. Output was defined as student achievement.

Definition of terms

A controlled ideal thermal environment is, for purposes here, an environment considered as ideal by thermal authorities. The environment that was considered as ideal will be described in detail in Chapter III.

A controlled deviate thermal environment is an environment considered non-optimum by thermal authorities.

Student learning was defined as achievement in teacher-made tests.

---

[8] _____, "Thermal Comfort and Efficiency," Overview, 3:23, August 1962.

CHAPTER II

REVIEW OF RESEARCH AND LITERATURE

The purpose of this chapter is to extensively review the research and literature concerning the effect of a controlled ideal thermal environment on students' achievement. First an analogy is given of a controlled thermal environment and air conditioning. This is followed by a review of the research and literature in both education and engineering relative to the effects of an ideal thermal environment on achievement. The effect of environment on health is examined briefly. Next a look is given to some historical comments on the effect of a proper thermal classroom environment. A report of thermal conditions necessary before the installation of a mechanical cooling unit in school buildings is then examined. This is followed by a summary of the findings of the previous University of Iowa studies and the Pinellas County, Florida, experiment. The chapter is concluded with a summary of various authors statements of needed research relative to measuring the effect of an ideal thermal environment on students' achievement.

Thermal Environment and Air Conditioning

This paper will use the term thermal environment when referring to all thermal conditions that would affect students' comfort. A preponderance of writers used the more popular term air conditioning to mean the same thing:

> What is air conditioning? The American Association of Heating, Refrigeration and Air Engineers defines it as "the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space."[1]

Although it may be true that many people associated the phrase air conditioning with the cooling of air, air conditioning is more than the cooling of air. Because of the wide acceptance of the idea of air conditioning most writers used the term rather than controlled thermal environment. However, the writers in the field used the definition of the American Association of Heating, Refrigeration and Air Engineers, rather than the more limited definition - cooling of air.

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[1] W.D. Foutz, "Comfortable Climatic Conditions in School Buildings," National Council on School Construction, Proceedings of the Thirty-ninth Annual Meeting, Denver, Colorado, October 1962, pp.66-70.

Education Literature

Many authors in the professional educational field state that a controlled ideal environment will improve learning. Examples of these writings follow:

> Teachers have remarked: People laugh and say that the air conditioned school is for the benefit of teachers, but we say it is for the benefit of education. Children used to be hot, tired, and soaked in perspiration; now they are alert and attentive all day.[2]
>
> The school plant under consideration has been in usage throughout all four seasons. Teachers' comments indicated that their effectiveness and comfort increased as well as student learning. Some evidence exists to indicate that absenteeism was reduced, both student's and teacher's, due to lowered transmission of germs and disease.[3]
>
> But air conditioning's real value is in terms of educational productivity, the important - albeit hard to measure - goal.[4]
>
> Although we have not yet collected a body of evidence to prove it, we know that young people learn better when environmental conditions are right for them. Air conditioning may be considered as one of the components.[5]

---

[2] Harold C. Brantley, "United High School, Laredo, Texas," American School Board Journal, 148:65-68, June 1964.

[3] Manning, op. cit., pp. 22-23.

[4] _____, Overview, op. cit., October 1961, pp. 50-53.

[5] John Lyon Reed, "Architects Consensus: Air Conditioning: Yes, Windowless School: No," Nation Schools, 74:62-3, October 1964.

From the above quotations one can readily observe that the authors of these articles implied that an ideal thermal environment does improve students' learning. However, none of the articles contained research data to substantiate their implications. These implications were not limited to those writing in periodicals. Mincy in his dissertation stated as one of his assumptions, "the thermal environment of a school is one of the environmental factors which affects, to a certain extent, the teacher-learning process."[6] Mincy did not attempt to measure the effect of the environment on learning.

The 1962-63, 34th edition of the *American School and University* contained two articles that implied that a positive relationship exists between the thermal environment of a classroom and learning. Both Lawrence Slote and Maurice J. Wilson in their articles in the 34th edition of this publication wrote about this relationship.

Slote explained:

> The application of air conditioning is an obvious and important aspect of human comfort in school and college buildings. Air conditioning is mainly concerned with the correction of

---

[6] H.F. Mincy, "A Study of Factors Involved in Establishing A Satisfactory Thermal Environment in the Classroom," Unpublished Doctorial Dissertation, University of Tennessee, Knoxville, 1961, p. 3.

> abnormal atmospheres and the consequent promotion of comfort, health and efficiency.[7]

Slote, after advising the maintenance of a proper classroom thermal conditions for comfort, health, and efficiency, quoted Charles D. Gibson of California:

> Charles D. Gibson, Chief of the Bureau of School Planning, California State Department of Education has stated, "Thermal comfort is not a luxury. It is a physical and mental requirement for effective use of a classroom. Schoolroom discomfort means inattention, restlessness, poor behavior habits and a minimum of ability to maintain attention to any mental task."[8]

Wilson in his article stated that air conditioning was being purchased because it provides better learning conditions:

> Air conditioning of educational buildings at the elementary, secondary and college levels is proceeding at a pace educators, architects and taxpayers would have thought preposterous five years ago. Basically, air conditioning is being purchased because it provides better teacher-learning conditions.[9]

Wilson continued by citing both the number of schools air conditioned in 1960 and the reasons why they were built with a controllable thermal environment:

---

[7] Lawrence Slote, "Achieving Thermal Comfort in Educational Building." American School and University, 1962-63, 34th edition, p. C1.

[8] Ibid., p. C1.

[9] Maurice J. Wilson, "Trends in Air Conditioning for Schools and Colleges," American School and University, 1962-63, 34th edition, p. C5.

> The 1960 *American School and University* Construction Census release showed that 913 schools and college buildings completed in 1960 were partially or completely air conditioned.
>
> Investigation into the reasons for air conditioning any one school will uncover three or four motivations. Improvement of learning and teaching efficiency and effective use of the educational plant for a longer portion of the year are perhaps the strongest reasons.[10]

Archibald B. Shaw while editor of *Overview*, in an editorial wrote:

> *Learning* is the activity in an educational plant; education is the product. The plant exists to promote learning. When this becomes clear, we can easily visualize the difference it makes when a sweaty student, struggling with sticky papers, is transformed into a cool and comfortable person at work in an environment that supports rather than detracts from his learning.[11]

In a different issue of *Overview*, another article discussed the relationship between an ideal thermal environment and efficiency, noting that research in the area was limited. The article stated, in part:

> Thermal Human Comfort is one factor in student efficiency. Though research in the area is limited, empirical observation bears

---

[10] *Ibid.*, p. C6.

[11] Archibald B. Shaw, "Lag in Air Conditioning", *Overview*, December 1962.

> out this statement. We know, for instance, that schoolroom discomfort breeds inattention, restlessness, and poor behavior and results in a lessening of mental retention.[12]

Superintendent of Schools, Edwin Estell was quoted in School Management as follows:

> To my way of thinking no one really knows what all the advantages of air conditioning are. The possibilities that exist in an air conditioned school are just beginning to be opened up.[13]

Superintendent Estell has several air conditioned schools in his school district. Mr. Estell is the District Superintendent of the Metropolitan School District of Lawrence Township, Indianapolis, Indiana.

Those writing about the effect of a controlled thermal environment on learning were not limited to the field of education. Henry Wright, former editor of Architectual Record quoted a statement by Architect John Lyon Reed: "We know that young people learn better when environmental conditions are right for them."[14]

---

[12] _____, "Thermal Comfort and Efficiency," Overview, August 1964, p. 25.

[13] _____, "How to Take Advantage of Air Conditioning," School Management, July 1962, p. 92.

[14] Henry Wright, "Air-Conditioning, Architecture, and Education," Architectual Record, August 1964, p. 145-150.

A recent development in the building of new education facilities has been the "underground" school. When a schoolhouse is constructed entirely underground it is necessary to completely control the environment of that building. Obviously such buildings have been the topic of much discussion and evaluation:

> In a recent survey, my recorded notes show that such schools (underground with a controlled thermal environment) had more places to display things, were dust free, had fewer disturbances, were thermally comfortable, were visually balanced, were less fatiguing, induced more stimulating learning, and were less expensive to operate and maintain. Teachers reported the children were learning more than they ever did under conventional class disturbances.[15]

The article failed to state upon what basis the teachers reported the children were "learning more than they ever did" under conventional class disturbances. Perhaps the teachers expressed this opinion because the pupils' behavior was better. In fact, Dillard reported this as one of the advantages of such a school. "Student behavior was better in the windowless wing (which was air conditioned) than in the conventional wing."[16] Appearing in the same article, the entire justification for the windowless (which must be air conditioned) school was improvement in work output.

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[15] George J. Collings, "Evaluation of Windowless Classrooms," National Council on Schoolhouse Construction, Proceedings of the Thirty-eighth Annual Meeting, Atlanta, Georgia, October 1961, p. 59.

> We all know - and this is the entire justification of the windowless school - that people do their best work when free from body stress and physical discomfort.[17]

Other authors have written about other advantages of air conditioning:

> Superintendent Taylor recalls: During summer school we almost had to chase the students outdoors. They (the students) know that they are going to school in comfort and they take a lot of pride in it.[18]

McQuade wrote a book Schoolhouse, in which he told of some of the problems involved in air conditioning:

> Ventilation needs are closely tied to acoustical needs, generally contradicting. Frequently you want to close a building up for acoustics, but open it up for circulation.[19]

McQuade stated that the teacher's comfort as well as the student's comfort was vital for the optimum learning.

---

[16] Philip H. Dillard, "No Windows, Please . . .And Put It Underground," Audio-Visual Instruction, October 1962, 7:534.

[17] Ibid., p. 535.

[18] _____, School Management.

[19] Walter McQuade, Schoolhouse, Simon and Schuster, New York, 1958, p. 149.

> If the environmental conditions are not optimum, they (children) do something about it. Pity the teacher in a hot or cold classroom. The class may pessmize (sic) her. Comfort - their comfort and hers - is not a luxury, but a physical and mental requirement.[20]

Manning and Olsen wrote that the teachers in an ideal thermal environment believe they are better teachers in such a classroom:

> Teachers' replies indicated that their effectiveness and comfort increase as well as student learning. Some evidence exists to indicate that absenteeism was reduced, both student's and teacher's, due to lowered transmission of germs and disease.[21]

Perhaps a thermal environment will increase students' achievement simply because students' attendance at summer schools will increase. Reported Brantley:

> Attendance is already better than last year, and enrollment has increased by twenty-five percent. The retention (better daily attendance) rate is also expected to be higher.[22]

One of the country's foremost educational consultants said, "All college buildings should be air conditioned for year-round use."[23]

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[20] Ibid., p. 175.

[21] Manning and Olsen, op. cit., p. 23.

[22] Harold C. Brantley, "United High School, Laredo, Texas," American School Board Journal, June 1964, p. 66.

Although many writing in educational publications implied that an ideal thermal environment would improve student achievement, they failed to identify research to substantiate their implications.

In recent years nearly all newly constructed commercial buildings have been equipped with controllable thermal environments. Why has this happened?

> Many business firms actually figure they save money by investing in air conditioning equipment -- their employees do better work if they are comfortable. In the same way, efficiency in learning may be the pay-off for cooling schools.[24]

Engineering Literature

Why have so many in the private sector of the economy air conditioned their factories? By seeking to find the answer to this question it was necessary to examine the literature of those who designed these factories:

---

[23] Engelhardt, Engelhardt and Leggett, "Educational Specifications for New College Facilities," A Study of Bulter County Community College, Bulter County, Kansas.

[24] McQuade, op. cit., p. 186.

Cliff Cornell, Plant Engineer of Industrial Nucleonics, Columbus, Ohio, said: "Air Conditioning has proved to be so beneficial to us that we would not consider building a new plant without it."[25]

Eugene A. Sloane has done considerable research regarding the value of air conditioning in a factory:

> We found foremen, production supervisors and personnel directors raving about the benefits. We found foremen saying things like: I know production in my department went up 25 per cent after cooling, and that's conservative.
>
> In case after case, we heard work managers say: I don't know how we ever got along without air conditioning in the plant . . but I do know that we'd have to shut down now if it were shut off.
>
> With a 40 year life, a payout period of 6.2 years results. The approximate rate on return of investment in air conditioning is 16 per cent.
>
> Mr. August R. Bozzo, Vice President of Bulova Watch Co., Jackson Heights, New York, was most emphatic about the need for year-around temperature and humidity control. "We'd go out of business tomorrow without air conditioning."[26]

Sloane then listed sixteen reasons why a factory should be air conditioned:

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[25] Eugene A. Sloane, "Why It Pays to Air Condition Factory Production Areas - Part II, "Air Engineering, February 1963, p. 35.

[26] Eugene A. Sloane, "Why It Pays to Air Condition Factory Production Areas - Part I," Air Engineering, January 1963, pp. 22-44.

1. Increase employee efficiency, up to 10 per cent annually
2. Good return on investment in cooling system, up to 122 per cent
3. More production up to 70 percent
4. Better quality control fewer rejects - fewer errors - up to 30 per cent.
5. Maintenance savings, less dust, etc. - up to 50 per cent
6. Humidity control for comfort and process
7. Reduced absenteeism during hot weather - up to 20 per cent
8. Reduced training expense from labor turnover - up to 30 per cent less.
9. Reduced labor turnover
10. Fewer union grievances
11. More good will, morale
12. Better competitive position in labor market
13. Reduced accident rate
14. Longer life of plant facilities operating in clean, dry air at reduced operating temperature
15. Improved customer relations due to fewer field product failures.
16. Reduced hiring expense, personnel department cost.[27]

It is of interest to note that at least ten of these reasons could be a basis for providing a controlled thermal environment in the classroom.

Hospitals as well as factories are being air conditioned:

---

[27] *Ibid.*, p. 26.

> Toronto: A recent survey showed that the extra cost of full year round hospital air conditioning, both initial and operating, could well be repaid out of increased staff efficiency.[28]

Several authors writing in professional engineering magazines have attempted to make a strong case for air conditioning school buildings. Ring stated:

> In industry and commerce, the fact that controlled thermal environment pays rather than costs is well accepted; but arguments against such thinking for schools are numerous, and often vociferous. Nevertheless, a fully controlled thermal environment can contribute immensely to the efficiency and effectiveness of the educational process, and its application in schools can be defended and justified.[29]

Dr. Ciomi wrote that air conditioning improves both the students' learning conditions and the teachers' efficiency:

> Research and observation of students has established that the capacity for assimilating and retaining knowledge is highest when the students are in a stress-free body condition. Such a condition also enables teachers to give undivided attention to their classes and, thus, increase their efficiency.[30]

---

[28] _____, "Hospital Air Conditioning Pays for Itself, Survey Shows," Air Engineering, July 1963.

[29] Robert C. Ring, "Thermal Environment for Schools," Heating, Piping and Air Conditioning, April 1966, pp. 109-111.

[30] Dr. Marcello Ciomi, "Air Condition Underground Buildings for Use as School or Shelter," Heating, Piping and Air Conditioning, June 1963, pp. 125-131.

Foxhall in the Architectual Record investigated the matter of students' learning in a controlled ideal thermal environment:

> Thermal comfort is not a luxury. It is a requirement for the philosophy and mental effective use of a classroom. Schoolroom discomfort means inattention, restlessness, poor behavior habits and a minimum of ability to maintain substained attention to any mental activity.[31]

Foxhall, although in an indirect way, admitted to a lack of research evidence showing the increased learning of youngsters attending thermal controlled classrooms:

> Many teachers are reluctant to state the effect of a good classroom environment on improving the grades achieved by students because of the difficulty of comparison with those in non-air conditioning schools.[32]

Foxhall did point out that due to lack of research concerning the effect of an ideal thermal environment on learning, air conditioning was being evaluated by non-scientific methods:

> Dr. Johnson (Superintendent of Schools) pointed out that the evaluation of air conditioning as a factor in school environment must be measured by the judgment of the teachers, the staff, the counselors, and the administrators.

---

[31] William B. Foxhall, "Air Conditioning for Schools," Architectual Record, July 1961, pp. 183-184.

[32] Ibid., p. 184.

> These judgments are based on many years of experience and seem valid although not statistically conclusive:
>
> 1. Attendance at the Eunice Smith School (which is air conditioned) is "a little better" than in the rest of the school system during warm months.
> 2. Achievement at the Eunice Smith School compares favorably with that in the rest of the school district.
>
> Some factual conclusions are:
>
> 1. The teachers are happier.
> 2. Students and teachers do a better job in warm months.[33]

Writing in the *Architectual Record* Harold B. Gores approached the need for controlling the thermal environment of the classrooms in terms of (1) National Defense, (2) key facilities of depressed areas, and (3) the increased productivity of the students:

> Nowadays people have come to regard the schoolhouse as the new arsenal of national defense where the maximum possession of decency and knowledge by each and every pupil is its chief weapon in trade. If this be the case, then how the schoolhouse performs - how it encourages and speeds learning - takes precedence over how indestructible it is and whether it will live out its days in janitorial ease.
>
> The key facility for neighbor renewal in depressed areas is the schoolhouse, owned by everybody and serving everybody; the young by day, six days a week, and in the evening and on Saturdays, persons of all ages will gather at the school for educational, recreational or

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[33] *Ibid.*, p. 185.

> civic purpose. Because this facility will be working 4,000 hours a year, comfort of the occupants is as necessary to productive use as it is in any industrial or commercial property.
>
> Controlling the environment of the new school - or the old one for that matter - makes just as much sense for the school board as it does for any other corporate body concerned with the productivity of the occupants.[34]

Gores concluded the article with a statement of why controlling the thermal environment of the classroom was necessary:

> If learning is to be maximum, the young scholar needs to be protected from the enervating and distracting discomforts of an environment left to harsh and fickle nature.[35]

With the exception of the University of Iowa studies, only one study in which the effect of a controlled ideal thermal environment on students' achievement was reported. This study was not a tightly controlled research study; however its results were of interest:

> Another area of the study dealt with achievement of the students during two full academic years and two summer sessions. Pre and post tests were given for the various sessions and a comparison of the means of the scores were then expressed in mean gains. The

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[34] Harold B. Gores, "The Case for Controllment of Environment," The Architectual Record, July 1961, p. 163.

[35] Ibid., p. 163.

> comparisons included grade level, the different schools, and results of the many subtests of the pre and post test batteries. There were 193 different comparisons over the two year sessions and those of air conditioned schools had greater mean gains in 133 comparisons. In none of the seperate comparisons were there gains that the researchers felt were statistically significant, yet in many incidences the trends were in favor of the climate controlled school.[36]

The matter of students' discipline was also given a cursory examination in this particular study:

> The research team did feel that through observations there were more discipline infractions in the non-climate controlled school but that it was more of a minor nature, such as disturbance and restlessness.[37]

The kinds and numbers of students illnesses were also studied:

> The actual difference in number and types of illnesses within the different schools were very slight. Therefore, there were no clear relationships obtained between the health of students and the climate of the school - yet this is not to say that there were not interesting trends in the data that reinforced other findings about climate controlled schools.[38]

There are those who believe, even though research is lacking, that providing an ideal thermal environment in schools does increase student achievement. Some architects have sold boards of education on the value of air conditioning school buildings by the increase in students' learning such buildings would provide:

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[36] _____, "To Compact is to Air Condition," Air Conditioning Heating and Ventilating, April 1964, pp. 66-69.

[37] Ibid., pp. 66-69.

[38] Ibid., pp. 66-69.

> On dealing with school boards, Mr. Hartstern said, "We didn't make any headway at all until we started talking to them about what air conditioning would do to the learning process."[39]

However, all school boards approving air conditioning in their school buildings did not state such a building will improve students' achievement. One of the largest air conditioned school buildings ever built in New York City contained 319,000 square feet at a cost of $7,500,000. The reasons given for air conditioning this school building did not include increased student learning:

> They (School Board and Superintendent) reasoned that it might become equally prevalent in school that a school built today without air conditioning or proper preparation for it may become obsolete long before it had served its expected useful life of 50 years or more.
>
> Additional arguments for complete air conditioning were the trend toward increased use of schools during the summer months for special and makeup classes and the possibility of a 12 month curriculum eventually becoming quite

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[39] _____, "Symposium on Schoolroom Air Conditioning," Air Engineering, May 1962.

common.[40]

School districts that have school buildings with an ideal thermal environment have continued building them:

> This school (fully air conditioned) has prompted our office to take a careful look at air conditioning. We believe it will be the rule rather than the exception in the next few years.[41]

Health and the School Environment

Since this study was primarily concerned with the effect of an ideal thermal environment on students, it was necessary to examine the effect of a thermal environment on student health. It is generally accepted that the child who is unable to attend school regularly whether due to illness or other causes usually does not achieve well in school. A remark attributed to a survey team as they studied approximately 160,000 elementary Texas school children was: "If you want to keep your child healthy, don't send him to school."[42]

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[40] Lewis Smith, "Why and How a New High School is Being Fully Air Conditioned," Heating Piping and Air Conditioning, December 1962, p. 93.

[41] _____, "School With Heat Pump, Fixed Glass," Architectural Record, July 1961, p. 172.

Thermal environment does have an effect on the health of individuals. T.C. Holy stated: "From the health angle, the incidence of respiratory disease is assumed to be related to the kinds of ventilation."[43]

Daugherty wrote directly about the issue of thermal environment and health:

> When air is dry, moisture evaporates more readily from the skin and produces a feeling of chilliness even with the temperature at 75 degrees or more. Dry air also removes moisture from the nasal passages and the throat causing that tight, irritated feeling that is so uncomfortable. Itchy skin is also a frequent result of dry air. Annoying, uncomfortable static electricity "shocks" multiply in dry air.
>
> Relative humidity maintained at 35 to 40 percent alleviates all of these problems and gives most people a feeling of comfort and well being at a temperature of 70 degrees.
>
> Research studies on Pneumococcus Type I, the germ that causes pneumonia, Staphylococcus albus and Streptococcus hemolyticus group C by the departments of medicine and biochemistry at the University of Chicago showed that relative

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[42] Darrell Body Harmon, *The Coordinated Classroom*, The American Seating Company, Grand Rapids, Michigan, 1959.

[43] T. C. Holy, "Location, Construction and Equipment of Schoolhouses for Health," *American School Board Journal*, January 1942, pp. 19-20.

> humidities of 40 to 50 per cent quickly killed these airborne bacteria. In dry air or very humid air they survived much longer.
>
> Most doctors agree that humidity maintained in the middle range - 35 to 45 per cent - is generally more healthful than very low or very high humidities. Mid-range relative humidity reduces susceptibility to colds and other respiratory disorders because moist nasal passages and throat are more resistant to the causes of these problems.[44]

Health, efficiency and comfort as they are affected by the thermal environment were the subject of an article by Edward V. Dostal:

> Health - It has long since been well established by scientific study of human reactions to heat, cold, light, acoustics, and other comfort factors [illegible] individual mental alertness and physical well-being. In turn these affect ability to concentrate upon classroom activities.
>
> Undoubtedly the major factor in the school, as it is everywhere else, is the condition of the air.
>
> Uncontrolled heat that causes sharp fluctuations in temperature, makeshift ventilation that amounts to nothing more than a draft, and failure to provide correct cooling which is just as important as correct heating and ventilation -- all of these are costly.
>
> From the student - teacher health and efficiency standpoint the cost is incalculable,

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[44] Charles R. Daugherty, "Winter Humidification Key to Greater Comfort," American School Board Journal, August 1964, p. 44.

> as school administrators and boards well know. They also know, if there is a way to achieve acceptable classroom comfort the installation of any equipment that falls short of that goal is the poorest kind of dollar economy in first cost and in the cost of operation and maintenance.[45]

Historical Concern for Schoolroom Air

Controlling the thermal environment of a school building has been a rather recent development; however, concern over the thermal environment of the classroom is not. As early as 1832, William A. Alcott wrote an essay on the need for proper ventilation:

> Holes or windows should be made in the roof of every schoolhouse, that the impure air may sometimes be suffered to escape in that direction.
>
> At the present I will only add, that after every precaution in regard to ventilation, which human wisdom can devise, every pupil should be required, and, if necessary, compelled to go out into the open air, at least once in an hour. Probably once in half an hour is not too often.[46]

Mr. Alcott also reported failure to provide proper ventilation in classrooms as the great cause for teachers leaving the profession:

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[45] Edward V. Dostal, "Providing for the Thermal Environment," American School Board Journal, January 1962, pp. 34-37.

[46] William A. Alcott, "Essay on the Construction of Schoolhouses," Hilliard, Gray, Little and Wilkens, Boston, 1963, pp. 14-15.

> In looking back upon the languor of fifty years of labor, as a teacher, reiterated with many a weary day, I attribute a great proportion of it to mephitic air; nor can I doubt that it has compelled many worthy and promising teachers to quit the employment. Neither can I doubt, that it has been the great cause of their subsequent sickly habits, and untimely disease.[47]

In the essay, Mr. Alcott expressed the feeling that it is inexcusable to make a child live in a poor classroom thermal environment:

> How preposterous and inexcusable would every one regard it, to give them (school children) their food constantly mingled with poison, or their drink with pernicious and loathsome insects. Yet it is not less inexcusable to furnish them with half corrupted air, or that which contains poisonous gasses! The food is given but three times a day; while the air is administered every moment. The child is at liberty to receive or reject food; but he is forced to breathe the air in which we place him.[48]

T. C. Holy took the following statement from the journal of Samuel Lewis, Ohio's first State Superintendent of Common Schools:

> The grounds on which the (school) house is built should be high, dry, removed from marshes, and stagnant water, not too near much traveled highways, yet having convenient access to it from every direction.

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[47] Ibid., p. 40.

[48] Ibid., p. 27.

> In towns and cities a lot should be selected, perhaps in the outskirts of the plat, certainly an open air situation, affording unobstructed light and air on all sides. This is much more necessary than is commonly supposed. If the house is dark, and ill ventilated, the children may be expected to be dull, and careless, and disorderly, and probably unhealthy.[49]

The above statement was written in the year 1838. During the years that followed a great deal of attention was given to providing the proper ventilation in the classroom:

> In the surge of school building that followed World War I much progress was made in improving thermal conditions in the classrooms. By 1929 the unit ventilator was the accepted standard.[50]

However, when the great depression settled over this country, schoolhouses were no longer constructed with unit ventilators. Unit ventilators were considered too "costly" to install in schoolhouses constructed during the depression.

Unit ventilators began to reappear in schoolhouses constructed following World War II. Beginning with the sixties, a few school buildings were air conditioned;

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[49] Holy, op. cit., pp. 19-20.

[50] W. D. Foutz, "Comfortable Climatic Conditions in School Buildings", National Council on School Construction, Procedings of the Thirty-ninth Annual Meeting, Denver, Colorado, October 1962.

most school buildings being built without complete thermal environment control had provisions for adapting the building to air conditioning should the need arise.

> There appears to be a definite trend in educational building toward providing more desirable environment air conditions whenever possible. This trend is growing out of a conviction on the part of educators that an atmospheric environment attuned to the student's needs pays indirect dividends in the form of better student-teacher relations, greater student satisfaction and comfort, and increased student efficiency in learning.[51]

Heating the schoolhouse is not the main problem in providing the ideal thermal environment in the classroom:

> Authorities are now in agreement that heating is no longer the central problem. Ventilation and cooling are the prime considerations in maintaining an optimal thermal environment.[52]

Mechanical Units Necessary

This section of the chapter presents the thermal conditions that are desirable to be maintained in a classroom. In the previous section it was stated that heating is no longer the central problem in providing the ideal thermal environment:

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[51] Slote, op. cit., p. Cl.

[52] Manning and Olsen, op. cit., pp. 22-23.

> It appears to me that the problem of what the design criteria will be based around should be answered. So often as adults, we listen to a teacher's or principal's remarks and are affected mostly by statements that we derive from their conversations when actually our design criteria should be based entirely on the children. I think that we could answer the question by this statement: "The child should not be distracted by the condition surrounding him."[53]

The 1965 edition of the *National Council on Schoolhouse Construction* contained information that spelled out an ideal schoolhouse thermal environment and the necessity for such an environment.

> The human body is more than a thermometer that senses the temperature of its environment and reacts to it. Changes in temperature, air flow, or humidity calls for adjustments in elaborate body temperature with amazing accuracy.
>
> No two researchers agree on exact combination of radiant temperature, air temperature, relative humidity, and air movement that constitutes the optimum. The general optimum ranges suggested are: balanced mean radiant temperatures; approximate air temperatures ranging from 69° to 74° F., relative humidity between 40 per cent and 60 per cent; and air movement of 20 to 40 cubic feet per minute.
>
> The tendency to make errors increases as the effect of the warmer surroundings put a greater stress on human adjustment.

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[53] Marvin R. A. Johnson, "Planning Thermal Comfort in Schooling Buildings," *National Council on Schoolhouse Construction*, Proceedings of the thirty-ninth Annual Meeting, Kansas City, Missouri, October 1959, pp. 27-30.

An optimum thermal condition at which most students are at their greatest efficiency is the object of a good thermal environment.

Optimum thermal conditions for students will vary according to their age, sex, level of physical activity, health, clothing density, and adaptation to local climate.

It is desirous, therefore, that average room surface temperature approximate room air temperature. To be somewhat more specific for an optimum environment with maximum learning efficiency in an occupied classroom; it is recommended that an air temperature of 72° F. be maintained when the mean radiant temperature (average temperature of surrounding surfaces) is at the same level as the air temperature. Deviations in the average surface temperature below (or above) air temperatures shall be compensated for by increasing (or decreasing) the air temperature in the ratio of 1.4° F. change in air temperature for every 1° F. change in average surface temperature.

Factors which influence comfort but which are not directly concerned with the production or removal of heat includes odors, dust, dirt, and other atmospheric contaminants such as smoke, exhause fumes and the like. These environmental and related factors should be controlled to the highest extent possible in order to provide satisfying thermal conditions.

Air motion within occupied space will, at the sitting level, provide air velocities ranging from 20 to 50 FPM. The air should be introduced into the occupied space in such manner that pockets of stagnant air are nonexistent. There should not be hot or cold air movements on occupants which cause discomfort.

All air supplied to occupied space should be passed through cleanable or replaceable air filters to reduce the air-borne dust.

> The relative humidity of a schoolroom should not be permitted to go below 25 percent nor above 60 percent.
>
> Sudden fluctuations of heating or cooling in room air temperatures due to equipment going on and off should not be more than ± 1° F., and preferably less.
>
> Room air temperature should not vary more than ± 1° F., vertically or horizontally up to the five foot level and to within one foot of exterior walls.[54]

If heating is no longer the central problem in providing the ideal thermal environment in the classroom, at what temperature is it necessary to cool the classroom air?

> When outside air is above 60 degrees classrooms are sure to be uncomfortable; even in northern cities in moderate weather classroom temperatures rise out of control.[55]

A study was conducted to discover when schoolhouse cooling was necessary:

> According to a study by John J. Nesbitt, Inc., year round air conditioning systems are justified in schools only if there is to be extensive use of classrooms at outside temperatures above 60° F., auditoriums at outside temperatures above 55° F., and offices at out-

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[54] *National Council on Schoolhouse Construction*, *op. cit.*, pp. 113-116.

[55] Manning and Olsen, *op. cit.*, pp. 22-23.

side temperatures of 75° F.[56]

Foutz reported the United States Government has set standards on when its buildings must be air conditioned:

> It is interesting to note the Federal Government handles air conditioning through the General Services Administration as follows: Whenever the Design Effective Temperature is above 80° F., buildings housing government employees must provide air conditioning, whether owned or rented by the government.[57]

Research has been conducted that permits a report on the percentage of time classrooms are in use when outside temperatures rises above 80° F. for various parts of the United States. Foutz continued:

> We went to United States Government figures on climatological data to determine what percentage of the hours the classrooms are in use when the outdoor temperature is above 80° F. We found some very interesting figures. In Los Angeles mechanical refrigeration is needed 86% of the hours. In other words, hardly a day goes by when mechanical refrigeration is not required if proper conditions in the classroom are to be maintained. In Washington, D.C. mechanical refrigeration is needed 44% of the time. And in Minneapolis - up in cold north country - nearly 25% of the school year is less effective if a school has no mechanical refrigeration. In Dallas, it's needed 62% of the classroom hours - well over half

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[56] Harry Terry, *Mechanical-Electrical Equipment Handbook for School Buildings*, John Wiley and Sons, Inc., New York, 1960, p. 210.

[57] Foutz, *op. cit.*, p. 69.

> of the school year. In Tampa, the percentage is 93%. In Jacksonville, Florida, 83% of the classroom hours are above 80° and are overheated invariably if the classrooms do not have mechanical refrigeration. In Chicago, 32% of the classroom hours are above 80°. In St. Louis 43% and in Cleveland, 34%. Mechanical refrigeration, then, has always been needed in schools throughout the country to obtain the maximum benefit from education the entire school year.[58]

One of the nation's largest manufacturer of heating and air conditioning equipment reported in its literature that students will profit greatly from an ideal thermal environment:

> Students experience roughly a 2% reduction in learning ability for every degree the room temperature rises above the optimum. Thus, for maximum learning efficiency, it is essential that adequate cooling as well as heating be provided in the classroom throughout the year. .
>
> Air conditioning also improves attendance in the spring and fall months. Many absenteeisms results from the discomfort associated with overheating.[59]

As in other previous statements telling of the gains to be realized through an ideal thermal environment, no reference was given upon which the figures were based.

Slote summarized the problem of stating the criteria for selecting the proper mechanical units that are necessary to maintain the ideal thermal environment:

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[58] Ibid., p. 69.

[59] _____, The Changing Pattern of Education and the Contribution of Air Conditioning, John J. Nesbitt, Inc., Philadelphia, Pa.

> It is impossible to set optimum air condition standards for all situations because the determinants which make up the standards or so-called comfort zone, are quite subjective. These determinants vary with age, sex, body build, clothing, activity, attitudes, and the adaptability characteristics of the individual.[60]

University of Iowa Studies

An extensive review of the literature revealed only one source of written research that was comparable to this study. This one study was conducted in joint cooperation by staff members of Educational Psychology and Educational Administration at the State University of Iowa, Lennox Industries Inc., and the Saydel, Iowa School District.

Peccolo's Study

Dr. Charles Peccolo was the researcher for this study. The study involved 44 matched pairs of fourth grade students and were divided into four groups. Each group was in the study for three weeks. Two groups were taught in the model environment and two groups in the regular (called marginal) classroom environment. Students in the model classroom were referred to as the experimental group. The measuring tasks for his study consisted of a repeated series of ten paper and pencil tasks. The study was conducted from March 19, 1962 to May 1, 1962. The results of the study were:

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[60] Slote, op. cit., p. 61.

> On the whole, the experiment showed large improvement on the part of every child taking part in 10 types of work. In every task, however, the experimental group which occupied the room with model thermal conditions, improved more than the control group. The results of the study were:
>
> 1. The significantly higher gains made by pupils in the experimental group indicated that the prescribed ideal thermal classroom environment was superior to the regular thermal environment for all reasoning and some clerical tasks.
>
> 2. The superiority of the experimental group on the new concepts task was not significant and may have been a chance difference.
>
> 3. The interaction between trials and levels and treatments indicated the prescribed ideal thermal classroom environment favored the experimental group in all the tasks, although the experimental effect varied in some tasks from level to level.[61]

McCardle's Study

A second study was conducted by Robert McCardle; however, the findings of this study have not been written as of this time. This experiment was conducted from

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[61] Charles Peccolo, The Effects of Thermal Environment on Learning, The Iowa Center for Research in School Administration, Iowa City, 1962, p. 29.

October 15, 1962, through December 14, 1962. In this investigation the learning experiment was conducted with sixth grade pupils in a model and a regular (called marginal) thermal environment. Some programmed learning materials were used to insure equality of instruction.

As stated above the complete results of this study are not yet in research form. Some of the results of McCardle's study are available. These were announced at a thermal environment conference in Chicago. As a result of this conference the following statements were written, author not listed, in the April 1964, issue of the American School Board Journal:

> The model room students performed significantly better than those in the marginal room for tests administered in the morning. But in the afternoon, the marginal-room results were a little better than the model room results. The researchers also reported that the high-ability learners in the marginal room did somewhat better than the high-ability in the model room, but the low-ability learners in the model room did better than their counterparts in the marginal room.
>
> In the vocabulary tests, the model room students did better than those in the marginal room. In considering the number of errors made in the program, the marginal room was much higher in number of errors made, with the model room tending to go through the program making fewer errors.
>
> There were far more errors in the marginal room in the morning; 1.3 in the model room and 1.9 in the marginal room. In the afternoon there was not much difference in the performance of the

> two, again indicating somewhat better performance in the afternoon than in the morning.
>
> The high-ability learners in the afternoon in the model room made 1.4 errors, and the marginal learners made 1.1 errors. For the low-ability learners, the errors increased tremendously as you moved from the model to the marginal room.
>
> It was also reported that in general the indications are that learning was more efficient in the model than in the marginal room, that the marginal environment seemed to have a more adverse effect on the low-ability learner than on the high-ability learner.[62]

Other Research

Pinnellas County Experiment

There is a dearth of literature regarding tightly controlled studies that have actually been completed concerning the effect of the thermal environment on learning. The Pinellas County, Florida, three year study did not control the learning experiences to which students were exposed. Although the Pinellas County study increased our knowledge about various aspects of a controlled thermal environment, generalizations concerning the effect of a model thermal environment on learning can not be made from this particular study.[63]

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[62] _____, Press Conference Report, "Two Studies on Thermal Environment and Learning," American School Board Journal, December 1963, pp. 22-24.

Needed Research

Several authors have noted that research measuring the effect of thermal environment on learning is needed. Concern over the absence of empirical data on the subject is apparent:

Mincy in his dissertation recognized the problem:

> Research in the area of the affect of the thermal environment upon learning has been rather limited.[64]

An article in *Overview*, author not given, said:

> Thermal human comfort is one factor in student efficiency. Though research in the area is limited, empirical observations bears out this statement. We know that school room discomfort breeds inattention, restlessness, and poor behavior and results in a lessening of mental retention.
>
> More statistical data relating air conditioning to student efficiency is also needed, not only to convince administrators of its importance, but because the thermal-conditioning system best for a particular school depends upon the kind of building, the climate, and the students involved. All of these factors must be weighed carefully before a thermal-comfort plan

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[63] Fred Stuart and H.A. Curtis, *The Pinellas County Experiment, Climate Controlled Schools*, Cooperative Research Project No. 1067, ASHRAE No. R.P. 36, 1964.

[64] Mincy, *op. cit.*, p. 5.

> is chosen. As things stand now, the school executive has little to base his air-conditioning decisions.[65]

The University of Michigan has conducted some related research in this area:

> The Department of Architecture at the University of Michigan reports that the University is conducting a case study on learning in windowless schools at Wayne, Michigan. The study, part of a larger research project supported by grants from the Education Facilities, seeks only to measure the importance of an outside view to the learning process.
>
> The report states that the larger study has so far been concerned mainly with a search of existing literature. The project finds the literature says much about the effect of light, heat, air, and sound on the physical comfort on students, but little on how or even whether physical comforts effect the learning process.
>
> Usually the question itself provokes the suggestion that a certain amount of discomfort may be essential to a good learning environment, the report continues. However, so far as we can discover, no one really knows or has even tried to find out. Indeed we find precious little agreement among educators and psychologists as to what constitutes the learning process itself; like many other humans, learning has always been taken for granted, and is now just beginning to be studied for its own sake.

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[65] _____, *Overview*, August 1962, p. 25.

> The task of evaluating any school environment is admittedly very complex.[66]

Wilson writing under the heading "Needs of the Time" stated:

> Educators are under greater pressure than ever to provide optimum teaching programs for gifted, average and retarded students. All this at a time when enrollments are increasing fast, taxpayer resistance is high and competition for teaching talents is keen. The administrator must search every avenue for efficient use of his instructional staff, plant facilities, and teaching aids. Air conditioning can supply the answer to many plant problems.[67]

Another reason why the effect of an ideal thermal environment for schools needs to be measured is the growing use of school buildings during the summer months. Carroll and Bareither recognized the trend toward increased use of school buildings:

> The educational building of tomorrow must be designed for year round comfort conditioning. A fast-growing population of school age children and education-minded adults means that the physical plant will be open many more hours each day and continuously through summer months.[68]

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[66] _____, "Current Study Probes Effects of Windowless Teaching," Audio-Visual Instruction, October 1962, p. 539.

[67] Wilson, op. cit., p. C12.

[68] J. Raymond Carroll and Harlan B. Bareither, "Comfort Conditioning for Educational Buildings," American School and University, 33rd edition, 1961-62, Cl.

School systems that do have air conditioned buildings keep constructing them without the necessary research as to their educational value:

> The advantage of air conditioning is that it provides a better environment for the teaching-learning process. Communities that have experience with air conditioned schools keep building them.[69]

The value of providing controlled ideal thermal environments in school buildings should be for the students' benefit:

> Schools and colleges are places of learning. The first consideration of their plant design are the welfare of the occupants and improvement of their learning opportunities.[70]

A challenge has been given to those in education regarding the value of an ideal thermal environment:

> The challenge for education is to pile up evidence on the contribution air conditioning makes to an efficient learning environment, and then to guide architects and engineers toward the construction of air-conditioned buildings within approved budgets.[71]

There are at least two persons, Peña and Thomas, who believe ideal thermal environment schools will not be built:

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[69] ____, "The Price of Better School Buildings," American School and University, 35th edition, 1963, pp. 47-50.

[70] ____, "Air Conditioning and the Learning Environment," Overview, October, 1961, p. 50.

[71] Ibid., p. 50.

> Despite all its virtues, air conditioning will still be considered a "frill" by the American public and for many years to come. Apparently it is easier to put a man on the moon than to air condition all our schools.[72]

Summary

Many statements can be found in literature implying that a relationship does exist in the classroom between an ideal thermal environment and students' learning. However, the research in the area is too limited to base the relationship upon scientific evidence. Apparently judgements have been made wholly upon subjective and non-scientific evidence. This study does contribute to our knowledge concerning the effect of environment upon learning.

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[72] William Peña and Joe B. Thomas, "Myths and Facts About Ventilation," *American School and University*, 35th edition, 1963, p. 42.

CHAPTER III

EXPERIMENTAL PROCEDURES AND CONDITIONS

Purpose of the Chapter

This chapter presents the experimental procedures and conditions that were followed during the course of the study.

Basic Procedure

Briefly the procedures followed in the study were as follows:

1. Twenty-two matched pairs of fifth grade pupils were selected from two classrooms.
2. A controlled thermal environment that was considered ideal was maintained in one classroom and in a second identical classroom a deviate thermal environment was maintained.
3. From each matched pair one student was placed in the controlled ideal thermal environment and the other student was placed in the deviate thermal environment.
4. The teaching of selected skills and subject areas was closely controlled. The instruction in the selected skills and subject areas was the same in both classrooms.
5. The students' achievement in the selected skills and subject areas was accurately measured.
6. Statistical tests were computed to measure student learning in the controlled ideal class-

> room thermal environment as compared to student learning in a controlled deviate classroom thermal environment.

Time of Year

The study was conducted for eight weeks and four days, September 7, 1965, through November 5, 1965. Schools in Iowa traditionally begin the last week in August or the first week in September. Since the study was conducted during ordinarily warm Iowa school months, it was necessary to use mechanical cooling units in order to maintain the desired ideal thermal classroom environment.

The study began one week after the Saydel School District started their school year and extended for eight weeks and four days (approximately one-fourth of a school year). By conducting the study during this particular period, not only was it possible to maintain strict control over the desired learning tasks, but it was felt that the motivation level of the two groups was more nearly equal at this time than at any other time of the school year.

Students

The students that participated in the study were fifth grade students of the Saydel School District, Saydel, Iowa. Fifth grade students were chosen for the experiment since (1) fourth grade students were used in the first study and sixth grade students were used in the second study, (2) the students were believed old enough to follow directions used in the various tests, (3) the researcher was interested in measuring pupil achievement in a concentrated period of handwriting lessons at this grade level, and (4) the availability of adequate programed science material for this particular grade.

Twenty-two matched pairs of students were selected for the study. The pairs of students in the two classrooms were matched on the following characteristics for this study:

1. Intelligence - based on the intelligence tests previously administered to the students.
2. Achievement - based on the results of the Iowa Test of Basic Skills. For matching purposes the overall composite score, the arithmetic composite score, and the spelling score of each pupil was used.

The results of the matching are summarized in Table II. This table lists the student number in column 1, the intelligence score in column 2, the overall composite score of the Iowa Test of Basic Skills in column 3, the arithmetic score on the test in column 4, column 5 has the students spelling score on the test, column 6 lists the age of the particular student, and the sex of the student is

TABLE II

GENERAL DATA FOR STUDENTS

GENERAL DATA FOR EXPERIMENTAL GROUP - GROUP A

Student	IQ	ITBS	Arith.	Spelling	Age	Sex	Father's Occupation
1	140	6.3	4.8	6.2	11	M	Painter
2	118	4.6	4.4	5.6	10	M	Rubber Worker
3	116	3.0	3.0	3.9	10	F	Factory
4	115	3.9	3.8	4.2	10	F	Unemployed
5	113	3.7	3.8	3.3	10	M	Bottler
6	110	4.0	2.7	6.6	10	F	Watchman
7	109	4.4	3.9	4.6	10	F	Heating
8	107	4.6	5.6	3.7	10	M	Disabled
9	105	2.8	2.8	1.5	10	M	Insurance
10	104	3.4	3.6	4.8	10	F	Welder
11	104	3.9	4.0	5.6	10	M	Mechanic
12	103	3.3	2.6	4.4	9	F	Service, Station
13	100	2.7	3.1	2.6	10	M	Mechanic
14	100	3.7	4.0	3.1	10	M	Carpenter
15	99	2.7	3.2	2.6	9	F	Painter
16	99	3.4	3.9	2.6	10	F	Manufacturer
17	98	2.6	2.7	2.5	10	M	Mechanic
18	97	3.2	3.4	1.9	10	M	Truck Driver
19	91	4.3	4.0	4.4	10	M	Cab Driver
20	91	4.3	5.0	5.6	10	F	Painter
21	90	3.0	2.9	5.9	10	F	Loader
22	89	2.5	2.6	2.6	11	M	Telephone Company
Sum	2298	80.3	79.8	88.2	220		
Mean	104.5	3.65	3.63	4.01	10.0		
S.D.	11.34	.87	.81	1.45	.43	M -12, F - 10	

TABLE II (Cont'd)

GENERAL DATA FOR CONTROL GROUP - GROUP B

Student	IQ	ITBS	Arith.	Spelling	Age	Sex	Father's Occupation
1	132	6.0	4.4	5.6	10	M	Driver
2	127	3.3	3.4	3.7	10	M	Driver
3	125	3.0	4.0	2.4	11	M	Manufacturer
4	118	4.5	4.8	5.1	10	F	Carpenter
5	117	3.2	3.2	3.7	10	F	Rubber Worker
6	116	3.8	4.2	3.7	11	M	Factory
7	114	4.0	3.6	4.8	11	M	Disabled
8	109	4.5	3.6	5.3	10	M	Maintenance
9	107	4.9	4.8	7.1	10	F	Feed Worker
10	107	2.3	2.2	1.7	10	M	Rubber Worker
11	105	4.4	5.2	6.2	10	F	Manufacturer
12	105	3.5	3.5	3.3	11	M	Welder
13	105	4.2	4.6	3.3	10	M	Mechanic
14	105	3.1	3.7	2.9	10	F	Truck Driver
15	102	3.6	3.6	3.7	10	F	Truck Driver
16	97	3.4	3.5	4.0	10	F	Housewife
17	97	3.2	2.6	2.8	11	M	Cab Driver
18	97	4.1	3.4	5.3	10	F	Painter
19	97	3.7	3.4	4.8	10	F	Truck Driver
20	81	2.5	3.0	1.9	11	M	Truck Driver
21	77	2.7	2.9	3.3	11	M	Mechanic
22	75	2.3	2.6	2.9	11	F	Truck Driver
Sum	2315	80.2	80.2	87.5	228		
Mean	105.2	3.65	3.65	3.98	10.4		
S.D.	14.58	.88	.76	1.36	.48	M - 12, F - 10	

listed in column 7. The remaining column in Table II contains information about each guardian's occupation.

Also shown in Table II are the means and standard deviations of each of the characteristics on which the students were matched. The mean intelligence quotient score for Group A was 104.5 and for Group B the mean was 105.2. Group A has a mean composite score on the Iowa Test of Basic Skills of 3.65. The mean on this test for Group B was also 3.65. Group A's mean on the Arithmetic Composite Score on the Iowa Test of Basic Skills was 3.63 and Group B's mean on the test was 3.65. The remaining score used for matching purposes was the spelling score on the Iowa Test of Basic Skills. On the spelling score of the test, the mean of Group A was 4.01 while Group B had a mean of 3.98 on the spelling section of the Iowa Test.

Both Groups A and B were subdivided into two levels. These two levels were (1) a high ability level and (2) a low ability level. The students in the two Groups had been matched on the previously cited criteria; e.g., Intellegent Quotient Scores and Iowa Test of Basic Skills Scores. Students having the identification numbers one through eleven were placed in the high ability level group and those students having the identification numbers twelve through twenty-two were placed in the low ability level group.

Selected statistics were computed following the placement of the students into the two levels; the groups were called the high ability level groups and the low ability level groups. The results of these computations are reported in Table III.

From Table III it can be seen that the mean intelligence score for the high ability level groups was 114.5 and for the low ability level groups the mean intelligence quotient score was 95.2. The mean composite score on the Iowa Test of Basic Skills was 4.02 for the high ability level groups and 3.27 for the low ability level groups. The high ability level groups had a mean score of 3.90 on the arithmetic composite score of the Iowa Test of Basic Skills and 3.37 was the mean for the low ability level groups. On the spelling score of the test the mean of the high ability level groups was 4.51 while the low level ability groups had a mean of 3.47 on the spelling section of the Iowa Test of Basic Skills.

Classrooms

Through the courtesy and cooperation of the Lennox Industries Inc. a Research School was made available for

TABLE III

GENERAL DATA FOR ABILITY LEVELS
GENERAL DATA FOR THE HIGH ABILITY LEVEL GROUPS
(Identification Numbers One through Eleven)

Experimental Group - Group A

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1241	44.6	42.4	50.0	111	
Mean	112.8	4.05	3.85	4.54	10.1	M=6
S.D.	9.79	.92	.83	1.39	.29	F=5

Control Group - Group B

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1277	43.9	43.4	49.3	113	
Mean	116.1	3.99	3.94	4.48	10.3	M=7
S.D.	8.52	.98	.82	1.54	.44	F=4

Combination of High Ability Level Groups

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	2518	88.5	85.8	99.3	224	
Mean	114.5	4.02	3.90	4.51	10.2	M=13
S.D.	9.32	.94	.83	1.47	.39	F=9

TABLE III (con'd)

GENERAL DATA FOR THE LOW ABILITY LEVEL GROUPS
(Identification Numbers Twelve through Twenty-Two)

Experimental Group - Group A

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1057	35.7	37.4	38.2	109	
Mean	96.1	3.24	3.40	3.47	9.9	M=6
S.D.	4.66	.61	.72	1.30	.51	F=5

Control Group - Group B

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1038	36.3	36.8	38.2	115	
Mean	94.4	3.30	3.34	3.47	10.5	M=5
S.D.	10.79	.59	.54	.91	.50	F=6

Combination of Low Ability Level Group

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	2095	72.0	74.2	76.4	224	
Mean	95.2	3.27	3.37	3.47	10.2	M=11
S.D.	8.36	.60	.64	1.12	.57	F=11

this study. This Research School located in Des Moines, Iowa, is for the specific purpose of finding new, improved and economical methods of providing different thermal classroom environment.

The floor plan of the school is shown in Figure 1.

The school has two classrooms. Each classroom has exactly the same square feet area (930 square feet). Both rooms are identical with one exception; one classroom's floor to ceiling height is eighteen inches greater than the other room. In the two previous studies carried out by the State University of Iowa the differences in floor to ceiling distance had no effect on pupil achievement and consequently both classrooms could be treated as though they were identical.

As previously stated, the school was not built for the specific purpose of carrying on regular classroom education. However, the school was designed by the architectural firm of Perkins and Wills of Chicago, Illinois. Both classrooms were so designed that each classroom was self-contained in all respects. Each room has its own book shelves. Located at the rear of each classroom is a pupil restroom.

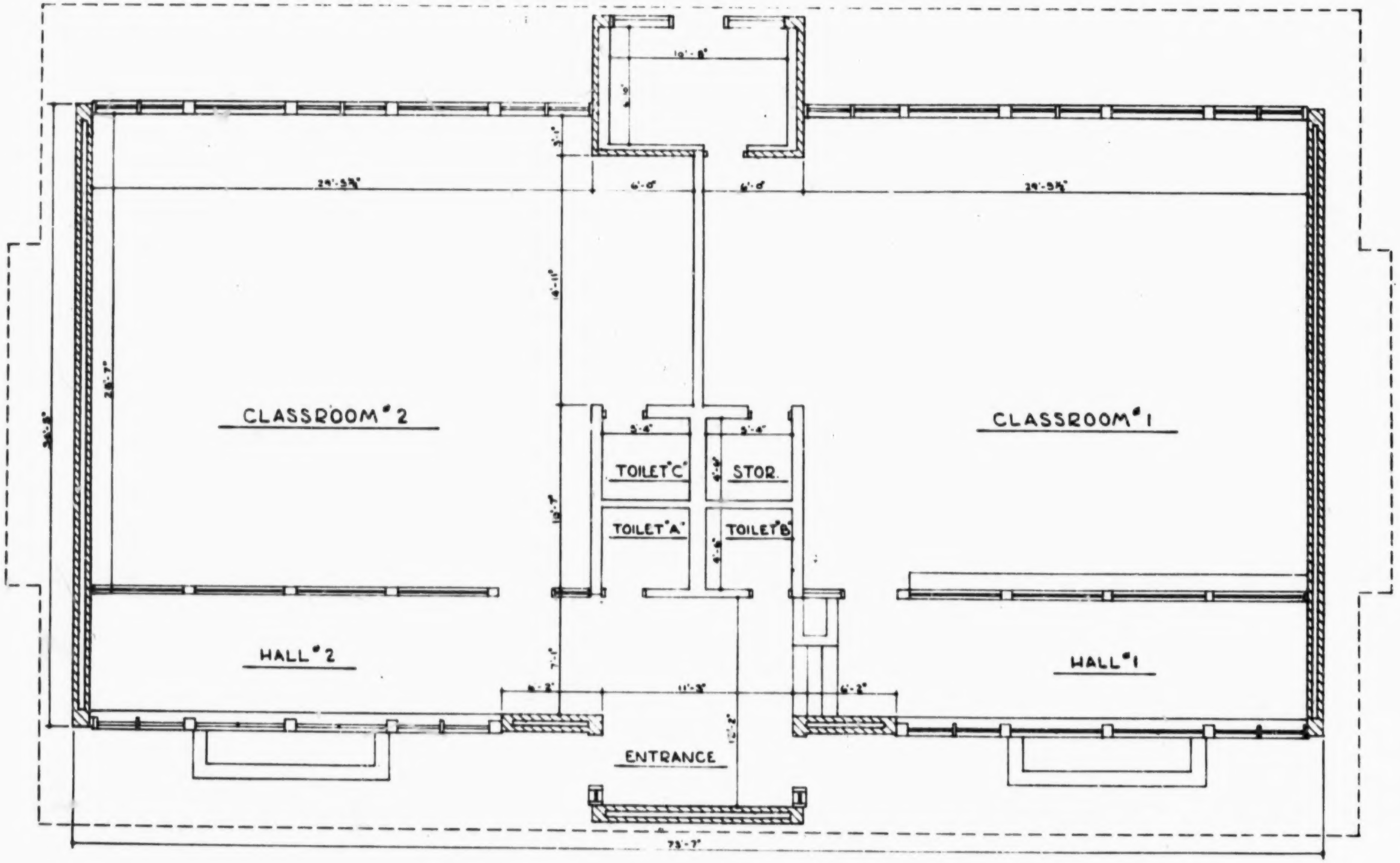

Figure I

FLOOR PLAN OF THE LENNOX RESEARCH SCHOOL

Also located at the rear of each classroom is the necessary mechanical equipment that is used to maintain the desired thermal conditions in either of the two classrooms. In addition this area contains the necessary instruments for measuring and recording the thermal environment of each classroom.

For the sake of completeness, the "U" Factors of the school house are reported: Ceiling and Roof .13; Exposed Glass 1.13; Exposed Walls .30; Floor East Room .95; Floor West Room 1.90. The "U" Factor is simply a measurement of the rate of heat loss in a building. The "U" Factors of the Research School are quite normal for school house construction in Iowa.

Lunch was served by a private catering service; however, the students that participated in this study paid the same price for their lunch as other Saydel students eating the lunch served by the Saydel School District. Each of the two groups of students involved in this study were served lunch in the hall at the Research School and brought the food back to their own classroom for eating.

Thermal Conditions

The mechanical units in the Research School were capable of maintaining the desired classroom thermal environment. For this study one classroom had a controlled thermal environment that was considered as ideal. In the second classroom a deviate thermal environment was maintained. At no time during the study was the thermal environment in the deviate thermal classroom the same as that in the controlled ideal thermal environment.

Using the experience gained in the first two experiments and after an extensive review of the literature, the following thermal environment was maintained in the Ideal Classroom:

1. Temperature in the range of 70°F. to 74°F. The mechanical equipment in each classroom maintained temperature to within a plus or minus one degree of the desired temperature.
2. Humidity was kept between 40 and 65 per cent.
3. Air movement was in the range of 20 to 40 fpm.
4. All classroom air was filtered through a blanket-type fiberglass filter.

Allowable temperature limits of 70°F. to 74°F. were established in the Ideal Classroom; the lower end of this range was considered optimum for the heating season and the upper range was considered optimum for the cooling season. The difference between optimum winter and summer temperatures was based on the results of a study conducted by the

American Society of Heating and Air-Conditioning Engineers. This study indicated that occupants were comfortable at a higher temperature in summer than in winter.

The thermal conditions of a classroom in the students' regular home school were also recorded every hour of the day during the study. This classroom was chosen since its location corresponded to the regular home classroom of the students who were in the deviate thermal classroom for this study. The thermal conditions of the "home" classroom are reported in Appendix A.

The following thermal environment was maintained in the deviate classroom:

1. Temperature was kept at a minimum of 76°F.
2. Humidity was allowed to flucate as in a typical classroom.
3. Air movement, when heating was required, was in the range of 20 to 40 fpm.
4. The teacher of the deviate classroom was free to open windows, turn on fans, or open doors as she might in her regular home classroom.

Thermal Measurement Instruments

Several instruments were used to measure the thermal data used in the study. All the measuring instruments that were used are known to be highly accurate in measuring air temperature, relative humidity and air movement. A Research Engineer employed by Lennox Industries Inc. was assigned to the study. He carried out all the thermal tests and maintained the thermal conditions used in this study.

Two Taylor mercurial thermometers having a range of 20°F. to 120°F. were used as calibration instruments.

A 12 point Type 153 Electronik Recorder, Model No. 153X72P12-X-26 with type J thermocouples was used to provide a continuous printed record of temperatures, dry bulb and wet bulb readings. This recorder was capable of recording thermocouple readings from -50°F. to 200°F. This recorder was calibrated to an accuracy of one-half of one degree. The recorder printed the thermocouple readings in multicolor in a cycle of one reading every five seconds. The chart speed was 24 inches per hour. Recorded on the chart were four air temperature readings at the student's desk level; one temperature reading was taken in each quadrant of the classrooms. Also recorded on the chart was a dry and wet bulb reading of the mechanical psychrometer. For every minute between 0800 hours and 1600 hours the chart had 12 readings, six for each room.

To insure the accuracy of the thermocouple readings, the Research Engineer checked the recorder two times each day with the Taylor mercurial thermometer.

The mechanical psychrometer used to measure humidity at the student desk level had a standard wick and gave wet and dry bulb readings. One mechanical psychrometer was located in each classroom. The accuracy of the mechanical psychrometers was checked twice each day with a sling psychrometer.

A vane-type anemometer was used to measure the velocity of the air discharged into the classrooms by the mechanical equipment. The air movement at student desk level was measured with an Anemotherm-Model 60 hot wire anemometer. This is a thermal-type anemometer and gives a direct reading of temperature, velocity and static pressure. It has an accuracy that is acceptable for most laboratory work.

In the students' homeroom at the Norwoodville Schools a Brown Instruments Thermo Humidigraph was the instrument used to record temperature and humidity continuously on a 24 hour chart. This was a Model 612X21KL-X-86 instrument manufactured by the Brown Instruments Division of Minneapolis-Honeywell Regulator Company. This instrument was capable of recording temperatures from 0°F. to 100°F. and of relative humidity from 0 to 100%.

A thermal condition of the Research School was recorded every five seconds of the day during the study from 0800 hours through 1600 hours. These recordings were of the thermal conditions in the ideal thermal environment classroom and in the deviate thermal environment classroom. The actual thermal conditions maintained throughout the study in both the controlled ideal classroom and the deviate classroom as well as the outside temperature and humidity are reported in Table IV for the hours 0900 through 1500.

Each day during the study the mean temperature was computed for the ideal thermal environment classroom, the deviate thermal environment classroom, and the outside temperature. For this computation the readings reported in Table IV were used. The results of these computations are shown in Figure 2.

Selection of the Control and Experimental Groups

The matched groups were placed in the control and the experimental group by a flip of a coin. Using this procedure, Group A students were placed in the experimental classroom and Group B students were placed in the controlled

TABLE IV

TEMPERATURE AND HUMIDITY RECORDINGS IDEAL CLASSROOM, DEVIATE CLASSROOM, OUTSIDE

Date	Place	Time 0900 T	 H	 1000 T	 H	 1100 T	 H	 1200 T	 H	 1300 T	 H	 1400 T	 H
Sept. 7	Ideal	76	68	73	[illegible]	75	[illegible]	72	61	75	75	74	7
	Deviate	77	70	81	65	81	69	80	71	78	75	80	7
	Outside	68	100	68	100	66	100	67	100	68	100	66	97
Sept. 8	Ideal	73	74	72	74	73	74	72	74	72	74	73	7
	Deviate	77	71	79	67	79	74	80	71	81	75	81	7
	Outside	61	100	62	100	63	100	67	97	69	97	71	9
Sept. 9	Ideal	74	79	74	64	74	64	75	67	75	67	76	6
	Deviate	81	81	84	73	81	63	88	64	89	64	89	7
	Outside	77	82	80	77	85	63	87	64	88	61	88	6
Sept.10	Ideal	71	56	72	47	75	48	72	[illegible]	72	50	72	5
	Deviate	79	54	80	50	81	52	82	52	80	56	80	5
	Outside	55	80	56	77	60	70	64	65	65	63	67	6
Sept.13	Ideal	73	74	74	70	73	[illegible]	74	75	73	70	73	6
	Deviate	79	70	81	71	82	69	82	72	82	71	83	6
	Outside	68	100	69	97	71	90	72	87	72	87	73	8
Sept.14	Ideal	71	74	73	74	74	74	73	70	73	61	74	5
	Deviate	75	61	81	62	81	60	82	[illegible]	82	69	83	6
	Outside	65	100	66	100	69	100	69	97	69	97	69	9
Sept.15	Ideal	74	54	74	55	74	47	73	51	73	54	73	5
	Deviate	77	56	80	47	81	50	80	50	80	47	81	4
	Outside	53	83	55	77	56	77	57	75	59	72	59	[illegible]
Sept.16	Ideal	72	57	75	62	74	61	73	61	74	56	72	5
		80	49	79	54	79	61	79	61	80	61	80	[illegible]
		55	100	54	100	55	100	56	100	57	100	59	10
Sept.17	Ideal	71	53	73	51	73	57	73	58	73	65	73	5
	Deviate	77	64	79	61	80	57	80	62	80	61	81	6
		57	100	57	98	59	96	63	90	62	90	63	8

SEC. 1

TABLE IV

TEMPERATURE AND HUMIDITY RECORDINGS
IDEAL CLASSROOM, DEVIATE CLASSROOM, OUTSIDE

Place	0900		1000		1100		1200		1300		1400		1500		Mean
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	Temp
Ideal	75	[illegible]	75	[illegible]	75	[illegible]	72	61	75	75	74	70	75	74	73.1
Deviate	77	73	81	65	81	65	80	71	78	75	80	75	75	79	78.8
Outside	68	100	63	100	66	100	67	100	68	100	66	97	66	93	67.4
Ideal	73	74	72	74	73	74	72	74	72	74	73	70	73	64	72.5
Deviate	77	71	79	77	79	74	80	71	81	75	81	79	80	83	79.5
Outside	61	100	62	100	63	100	67	97	69	97	71	94	72	94	66.4
Ideal	74	79	74	[illegible]	74	64	75	67	75	67	76	64	75	63	74.7
Deviate	81	81	84	75	81	83	88	64	89	64	89	70	89	66	85.[illegible]
Outside	77	82	80	77	85	65	87	64	86	61	88	61	87	66	84.[illegible]
Ideal	71	56	72	47	73	48	72	[illegible]	72	50	72	54	74	55	72.5
Deviate	79	54	80	50	81	52	82	52	80	56	80	54	82	54	80.5
Outside	55	80	50	77	60	70	64	65	65	63	67	61	67	52	62.0
Ideal	73	74	74	73	73	[illegible]	[illegible]	75	73	70	73	65	74	66	73.4
Deviate	79	70	81	71	[illegible]	63	[illegible]	72	82	71	83	68	75	69	81.1
Outside	68	100	65	97	71	90	72	97	72	87	73	87	75	84	71.4
Ideal	71	74	73	74	74	74	73	70	73	61	74	56	73	[illegible]	[illegible]
Deviate	78	61	81	62	81	[illegible]	82	[illegible]	82	69	83	68	82	[illegible]	[illegible]
Outside	65	100	66	100	69	100	69	97	69	97	69	93	69	93	68.0
Ideal	74	54	74	55	74	47	73	51	73	54	73	51	73	54	73.4
Deviate	77	56	80	47	81	50	[illegible]	50	80	47	81	44	80	46	79.8
Outside	53	83	55	77	56	77	57	75	59	72	59	69	59	79	56.8
Ideal	72	57	75	62	74	61	73	61	74	56	72	56	72	53	73.1
	80	49	79	54	79	61	79	61	80	61	80	58	80	64	79.5
	53	100	54	100	55	100	56	100	57	100	59	100	62	97	56.5
Ideal	71	53	73	61	73	57	73	58	73	65	73	57	72	57	72.5
Deviate	77	64	79	61	80	57	80	62	80	61	81	62	81	55	79.7
	57	100	57	96	59	96	63	90	62	90	63	87	61	90	60.2

SEC. 2

TABLE IV (Continued)

Date	Place	Time 0900 T	 H	 1000 T	 H	 1100 T	 H	 1200 T	 H	 1300 T	 H	 1400 T
Sept.20	Ideal	72	70	72	[illegible]	71	54	72	[illegible]	72	54	71
	Deviate	79	61	80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62	75
	Outside	60	100	60	100	[illegible]	100	63	100	63	67	63
Sept.21	Ideal	73	61	72	[illegible]	[illegible]	[illegible]	72	[illegible]	72	57	73
	Deviate	80	[illegible]	81	[illegible]	81	62	[illegible]	[illegible]	81	64	80
	Outside	60	93	61	90	61	[illegible]	[illegible]	94	[illegible]	[illegible]	56
Sept.22	Ideal	72	[illegible]	74	51	72	54	71	57	[illegible]	[illegible]	71
	Deviate	[illegible]	[illegible]	81	[illegible]	82	54	81	[illegible]	[illegible]	[illegible]	82
	Outside	57	80	61	71	65	63	67	71	[illegible]	[illegible]	68
Sept.23	Ideal	72	50	74	51	72	50	73	50	72	53	72
	Deviate	80	39	81	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75
	Outside	46	55	40	53	47	54	47	[illegible]	[illegible]	62	52
Sept. 24	Ideal	72	35	72	36	72	35	72	[illegible]	72	36	73
	Deviate	70	48	79	47	[illegible]	41	80	[illegible]	[illegible]	47	80
	Outside	43	76	43	73	45	[illegible]	49	71	52	61	54
Sept.27	Ideal	73	43	73	51	73	[illegible]	72	[illegible]	72	51	72
	Deviate	73	50	81	[illegible]	[illegible]	57	81	[illegible]	81	49	78
	Outside	45	90	45	98	47	90	43	100	45	100	40
Sept.28	Ideal	74	50	73	[illegible]	73	50	72	[illegible]	72	[illegible]	73
	Deviate	80	[illegible]	81	[illegible]	82	61	82	71	82	64	82
	Outside	65	67	56	70	73	58	72	[illegible]	74	62	75
Sept.29	Ideal	73	56	73	58	74	55	73	50	73	[illegible]	73
	Deviate	83	64	81	64	81	64	83	65	84	[illegible]	84
	Outside	66	61	69	73	71	71	73	69	75	71	75
Sept.30	Ideal	71	50	72	50	72	47	72	47	73	47	73
	Deviate	79	54	79	50	82	43	81	[illegible]	81	47	81
	Outside	49	83	50	93	49	77	50	74	52	74	51
Oct. 1	Ideal	74	44	73	44	74	41	73	44	72	40	73
	Deviate	80	47	80	47	82	48	81	44	[illegible]	[illegible]	81
	Outside	51	74	55	64	60	53	54	45	[illegible]	33	67

SEC. 1

TABLE IV (Continued)

Place	Time 0900		1000		1100		1200		1300		1400		1500		Mean Temp
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	
Ideal	72	70	72	[illegible]	71	64	72	[illegible]	72	54	71	53	73	55	71.4
Deviate	79	61	80	[illegible]	79	[illegible]	80	[illegible]	80	62	75	64	76	57	76.2
Outside	60	100	60	100	[illegible]	100	63	100	63	67	63	57	64	90	61.2
Ideal	73	61	73	[illegible]	72	57	72	[illegible]	72	57	73	54	74	51	73.3
Deviate	80	[illegible]	81	[illegible]	81	82	80	81	81	64	80	57	80	64	70.4
Outside	60	93	61	80	61	[illegible]	[illegible]	94	57	60	56	60	56	75	59.8
Ideal	73	[illegible]	74	51	73	54	71	57	72	57	71	56	73	55	72.1
Deviate	71	[illegible]	81	[illegible]	80	54	81	[illegible]	81	[illegible]	82	56	81	55	80.8
Outside	57	80	60	70	66	63	67	61	68	58	66	56	66	58	64.4
Ideal	72	50	74	51	72	50	73	50	72	35	72	35	72	35	72.4
Deviate	80	38	81	42	78	[illegible]	72	[illegible]	[illegible]	[illegible]	79	42	79	40	70.2
Outside	46	55	40	53	47	54	47	[illegible]	51	52	52	56	52	54	[illegible]
Ideal	72	35	72	[illegible]	72	35	72	[illegible]	73	36	73	36	73	40	72.4
Deviate	70	46	79	47	[illegible]	41	80	47	80	47	80	42	80	42	79.5
Outside	43	76	45	73	48	60	49	61	52	61	54	57	55	55	[illegible]
Ideal	73	40	73	51	72	[illegible]	72	[illegible]	72	50	72	50	72	50	72.4
Deviate	78	50	81	[illegible]	[illegible]	57	81	50	81	40	78	56	81	52	79.5
Outside	[illegible]	93	45	98	47	96	48	100	40	100	46	96	50	90	47.5
Ideal	74	50	73	[illegible]	73	50	72	[illegible]	73	54	73	61	73	54	73.0
Deviate	80	[illegible]	81	[illegible]	82	61	[illegible]	61	82	61	82	64	83	62	81.7
Outside	60	67	56	70	70	66	71	60	74	62	75	62	75	64	70.1
Ideal	73	56	73	53	74	56	73	50	73	58	73	54	73	56	73.1
Deviate	83	54	81	64	81	64	83	65	84	65	84	59	83	58	82.7
Outside	66	61	69	73	71	71	73	69	75	71	75	62	76	56	72.1
Ideal	71	50	72	50	72	47	72	47	73	47	73	47	73	47	72.2
Deviate	79	54	79	50	82	43	81	50	81	47	81	54	81	50	80.5
Outside	49	83	50	93	49	77	50	74	52	74	51	77	50	69	50.1
Ideal	74	44	73	44	74	41	73	44	72	40	73	40	73	40	73.1
Deviate	80	47	80	47	82	48	81	44	80	44	81	42	81	44	80.7
Outside	51	74	55	64	60	53	64	45	66	39	67	37	68	36	61.5

SEC. 2

TABLE IV (Continued)

Date	Place	Time 0900 T	 H	 1000 T	 H	 1100 T	 H	 1200 T	 H	 1300 T	 H	 1400 T
Oct. 4	Ideal	72	39	74	37	[illegible]	[illegible]	74	41	73	40	73
	Deviate	77	41	82	[illegible]	[illegible]	[illegible]	81	41	81	41	80
	Outside	53	60	[illegible]	[illegible]	[illegible]	51	61	[illegible]	63	40	66
Oct. 5	Ideal	71	40	73	[illegible]	[illegible]	[illegible]	[illegible]	62	74	47	73
	Deviate	80	[illegible]	81	[illegible]	80	[illegible]	[illegible]	48	82	49	82
	Outside	55	[illegible]	59	63	62	[illegible]	[illegible]	[illegible]	68	53	69
Oct. 6	Ideal	[illegible]	46	73	[illegible]	73	[illegible]	[illegible]	[illegible]	73	47	73
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	52	81
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	69	59	71
Oct. 7	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	35	73
	Deviate	79	44	79	50	[illegible]	44	79	44	81	42	79
	Outside	64	45	64	43	[illegible]	34	67	30	67	26	60
Oct. 8	Ideal	71	31	73	35	74	36	[illegible]	34	73	36	72
	Deviate	79	35	81	35	81	38	81	42	82	36	81
	Outside	57	40	50	44	59	42	62	30	63	37	65
Oct.11	Ideal	71	34	73	31	74	31	74	32	74	30	74
	Deviate	73	40	80	42	81	36	81	41	81	39	81
	Outside	57	45	51	37	59	37	61	[illegible]	62	26	61
Oct.12	Ideal	71	34	73	33	73	32	74	30	75	33	73
	Deviate	78	34	81	37	81	33	81	30	81	33	81
	Outside	47	43	55	45	60	32	64	30	66	29	67
Oct.13	Ideal	72	34	74	33	74	35	75	32	75	35	73
	Deviate	80	32	81	30	81	33	81	33	82	34	81
	Outside	53	56	56	45	59	40	61	35	63	37	64
Oct.14	Ideal	72	50	74	58	74	62	73	58	73	58	72
	Deviate	80	44	80	48	79	54	81	62	79	64	81
	Outside	62	81	64	61	64	81	65	54	68	76	68
Oct.15	Ideal	72	57	73	61	73	61	73	58	73	51	72
	Deviate	81	52	79	58	80	61	81	62	82	62	82
	Outside	82	93	64	90	65	87	69	76	72	71	75

TABLE IV (Continued)

Place	Time 0900 T	 H	 1000 T	 H	 1100 T	 H	 1200 T	 H	 1300 T	 H	 1400 T	 H	 1500 T	 H	 Mean Temp
Ideal	72	39	74	37	73	38	74	41	73	40	73	40	73	40	73.1
Deviate	77	41	82	28	79	39	81	41	81	41	80	42	80	32	80.0
Outside	50	60	58	56	58	51	61	44	63	40	66	38	66	40	59.8
Ideal	71	46	73	44	74	44	73	51	74	47	73	47	73	54	73.0
Deviate	80	44	81	49	80	45	82	49	82	49	82	52	83	49	81.4
Outside	55	64	59	59	62	60	65	54	68	53	69	51	71	43	64.0
Ideal	71	46	72	50	73	53	74	52	73	47	73	51	73	54	72.8
Deviate	[illegible]	[illegible]	80	47	[illegible]	48	[illegible]	50	81	52	81	48	81	44	80.2
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	69	59	71	44	72	34	66.5
Ideal	[illegible]	34	74	37	[illegible]	33	74	31	73	35	73	35	74	33	73.4
Deviate	78	44	79	40	79	44	79	44	81	42	79	43	79	39	79.2
Outside	64	45	64	43	66	34	67	28	67	28	66	32	65	34	65.4
Ideal	71	31	73	39	74	36	74	34	73	36	72	38	73	35	72.9
Deviate	79	35	81	35	81	38	81	42	82	36	81	38	81	38	80.8
Outside	57	40	58	44	59	42	62	36	63	37	65	33	64	32	61.1
Ideal	71	34	73	32	74	31	74	32	74	30	74	35	73	32	73.2
Deviate	83	40	82	42	81	36	81	41	81	39	81	42	80	35	81.2
Outside	53	45	51	37	59	37	61	28	62	26	61	27	61	27	58.2
Ideal	71	34	73	33	73	32	74	30	75	33	73	33	74	33	73.2
Deviate	78	34	81	30	81	33	81	30	81	33	81	36	80	35	80.4
Outside	47	42	55	45	60	32	64	30	66	29	67	28	68	27	61.0
Ideal	72	34	74	33	74	35	75	32	75	35	73	38	73	35	73.7
Deviate	80	32	81	30	81	33	81	33	82	34	81	33	82	34	81.1
Outside	50	56	56	45	59	40	61	39	63	37	64	37	65	37	59.7
Ideal	72	50	74	58	74	62	73	58	73	58	72	61	71	57	72.7
Deviate	80	44	80	48	79	54	81	62	79	64	81	56	81	52	80.1
Outside	62	81	64	81	64	81	65	84	68	76	68	76	67	70	65.4
Ideal	72	57	73	61	73	61	73	58	73	51	72	47	72	57	72.5
Deviate	81	52	79	58	80	61	81	62	82	62	82	62	82	65	81.0
Outside	62	93	64	90	65	87	69	76	72	71	75	67	75	57	68.8

TABLE IV (Continued)

Date	Place	0900 T	0900 H	1000 T	1000 H	1100 T	1100 H	1200 T	1200 H	1300 T	1300 H.	1400 T	1400
Oct.18	Ideal	71	60	73	58	73	51	73	51	73	51	73	5
	Deviate	77	61	80	58	82	55	83	53	83	55	84	5
	Outside	67	70	72	59	76	52	78	47	80	42	80	4
Oct.19	Ideal	73	58	72	57	73	58	74	58	73	54	73	5
	Deviate	78	54	81	55	80	57	82	55	81	58	82	5
	Outside	65	76	68	73	68	73	68	73	66	81	65	8
Oct.20	Ideal	72	54	73	51	72	54	72	54	72	54	72	5
	Deviate	77	54	79	54	75	52	80	50	80	54	81	5
	Outside	55	83	56	77	57	75	56	75	56	80	54	9
Oct.21	Ideal	71	53	73	51	73	50	73	51	73	50	73	4
	Deviate	77	52	79	47	79	49	80	47	80	47	79	4
	Outside	50	86	48	89	49	83	51	80	52	71	53	6
Oct.25	Ideal	73	37	72	43	72	46	73	47	73	47	73	4
	Deviate	79	31	80	35	81	38	80	40	81	41	82	3
	Outside	52	59	55	55	60	49	62	50	65	47	68	3
Oct.26	Ideal	71	41	73	47	72	49	72	46	73	47	71	4
	Deviate	78	30	80	35	79	36	80	40	80	35	80	3
	Outside	46	68	50	61	55	51	57	45	58	40	60	3
Oct.27	Ideal	72	41	74	44	74	47	73	51	73	50	74	5
	Deviate	78	35	80	38	79	42	80	41	81	35	82	3
	Outside	49	61	53	54	56	51	60	44	63	38	65	3
Oct.28	Ideal	71	60	73	47	73	47	73	44	73	44	71	4
	Deviate	76	41	78	41	79	40	79	47	79	43	79	3
	Outside	42	62	46	55	49	50	52	43	53	39	53	3
Oct.29	Ideal	72	34	72	50	73	47	74	47	73	50	72	5
	Deviate	82	38	78	33	79	37	79	40	81	40	81	3
	Outside	46	49	50	46	55	43	59	42	62	42	65	4
Nov. 1	Ideal	71	38	73	47	74	44	73	44	71	45	71	4
	Deviate	78	30	79	31	81	33	81	38	80	35	80	3
	Outside	42	70	51	54	56	43	59	36	61	31	62	3

TABLE IV (Continued)

Place	Time 0900 T	 H	 1000 T	 H	 1100 T	 H	 1200 T	 H	 1300 T	 H	 1400 T	 H	 1500 T	 H	 Mean Temp
Ideal	71	60	73	58	73	51	73	51	73	51	73	51	72	50	72.6
Deviate	77	61	80	58	82	55	83	53	83	55	84	52	83	52	81.7
Outside	67	70	72	59	76	52	78	47	80	42	80	42	80	41	76.1
Ideal	73	58	72	57	73	58	74	58	73	54	73	58	73	58	73.0
Deviate	78	54	81	55	80	57	82	55	81	58	82	58	82	55	80.8
Outside	65	76	68	73	68	73	68	73	66	81	65	87	65	84	66.5
Ideal	72	54	73	51	72	54	72	54	72	54	72	54	72	57	72.1
Deviate	77	54	79	54	75	52	80	50	80	54	81	50	80	54	78.9
Outside	55	83	56	77	57	75	55	75	56	80	54	90	53	90	55.5
Ideal	71	53	73	51	73	50	73	51	73	50	73	47	73	43	72.7
Deviate	77	52	79	47	79	49	80	47	80	47	79	46	79	42	79.0
Outside	50	86	48	89	49	83	51	80	52	71	53	69	54	61	51.0
Ideal	73	37	72	43	72	46	73	47	73	47	73	44	72	42	72.6
Deviate	79	31	80	35	81	38	80	40	81	41	82	38	80	39	80.4
Outside	52	59	55	55	60	49	62	50	65	47	68	39	68	37	61.4
Ideal	71	41	73	47	72	49	72	49	73	47	71	45	73	47	72.1
Deviate	78	30	80	35	79	35	80	40	80	35	80	32	80	34	79.5
Outside	46	68	50	61	55	51	57	45	58	40	60	39	60	39	55.1
Ideal	72	41	74	44	74	47	73	51	73	50	74	51	72	50	73.1
Deviate	78	35	80	38	79	42	80	41	81	35	82	30	78	37	79.7
Outside	49	61	53	54	56	51	60	44	63	38	65	35	64	35	58.5
Ideal	71	60	73	47	73	47	73	44	73	44	71	45	72	45	72.2
Deviate	76	41	78	41	79	40	79	47	79	43	79	39	80	38	78.6
Outside	42	62	46	55	49	50	52	43	53	39	53	38	54	35	49.8
Ideal	72	34	72	50	73	47	74	47	73	50	72	51	71	46	72.4
Deviate	82	38	78	33	79	37	79	40	81	40	81	39	82	39	80.2
Outside	46	49	50	46	55	43	59	42	62	42	65	41	65	43	57.4
Ideal	71	38	73	47	74	44	73	44	71	45	71	45	72	43	72.1
Deviate	78	30	79	31	81	33	81	38	80	35	80	32	80	32	79.8
Outside	42	70	51	54	56	43	59	36	61	31	62	30	62	30	56.1

TABLE IV (Continued)

		Time											
Date	Place	0900		1000		1100		1200		1300		1400	
		T	H	T	H	T	H	T	H	T	H	T	H
Nov. 2	Ideal	71	56	74	54	73	37	71	53	71	53	72	34
	Deviate	77	39	80	41	81	41	82	39	83	32	84	35
	Outside	58	62	63	56	66	50	71	42	73	41	75	36
Nov. 3	Ideal	72	46	74	44	73	47	72	[illegible]	73	50	72	47
	Deviate	78	37	80	35	82	39	81	36	81	41	81	36
	Outside	62	54	62	54	66	47	66	47	66	48	67	47
Nov. 4	Ideal	71	38	74	54	73	40	73	44	73	47	73	47
	Deviate	78	30	79	37	79	34	80	37	81	35	79	30
	Outside	57	73	41	65	44	58	47	51	50	43	52	43
Nov. 5	Ideal	72	30	74	44	75	47	72	50	72	50	71	49
	Deviate	76	29	79	29	79	34	80	40	80	38	81	33
	Outside	48	80	53	77	62	67	65	68	66	65	67	65

TABLE IV (Continued)

Place	Time 0900		1000		1100		1200		1300		1400		1500		Mean
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	Temp
Ideal	71	56	74	54	73	37	71	53	71	53	72	54	75	49	72.4
Deviate	77	39	80	41	81	41	82	39	83	39	84	35	83	35	81.4
Outside	58	62	63	56	66	50	71	42	73	41	75	39	76	38	68.6
Ideal	72	46	74	44	73	47	72	40	73	50	72	47	71	40	72.4
Deviate	78	37	80	35	82	39	81	36	81	41	81	38	81	41	80.5
Outside	62	54	62	54	66	47	66	47	66	48	67	47	68	44	65.2
Ideal	71	38	74	54	73	40	73	44	73	47	73	47	71	50	72.5
Deviate	78	30	79	37	79	34	80	37	81	35	79	30	80	32	79.4
Outside	37	73	41	65	44	58	47	51	50	48	52	43	52	43	46.1
Ideal	72	30	74	44	75	47	72	50	72	50	71	49	71	54	72.4
Deviate	76	29	79	29	79	34	80	40	80	39	81	38	80	43	79.2
Outside	48	80	53	77	62	67	65	68	66	65	67	65	67	63	61.1

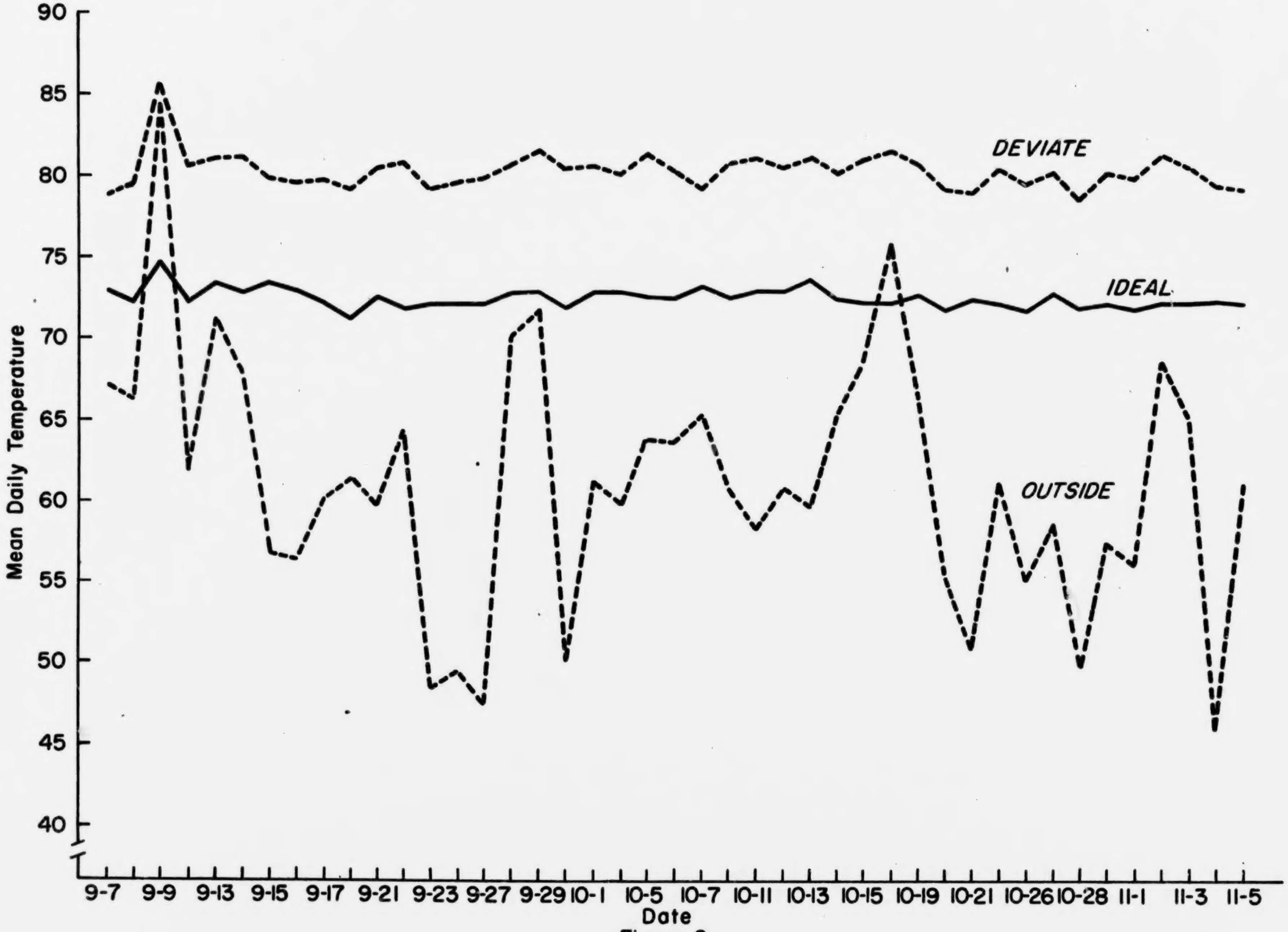

Figure 2

MEAN TEMPERATURE - IDEAL CLASSROOM, DEVIATE CLASSROOM, OUTSIDE classroom. The experimental group was placed in the classroom that had the controlled ideal thermal environment and the control group was placed in the classroom that had the deviate thermal environment.

Skills and Subject Areas

The specific learning skills and subject areas measured for this study were:

1. Spelling
2. Handwriting
3. Accuracy on an adding machine
4. Mathematics problems
5. Science

Four of these skills were selected as they involved regular elementary school subjects. Spelling, handwriting, mathematics and science are offered in nearly every elementary school. Accuracy on an adding machine was included as it approximates typewriting as a subject.

These five skills and subject areas were also selected as they involved a variety of learning aptitudes.

In addition to selecting the skills and subject areas for the above reasons, they were selected because student achievement in each area could be objectively measured.

The skills and subject areas were taught by an Iowa certified elementary teacher. The teacher and her role in the study is explained in greater detail later in this chapter. All skills and subject areas measured for this study were taught by the same teacher and presented to each class in as identical a method as humanly possible. At all times the skills and subject areas were presented to both the control group and the experimental group using an accepted teaching method. The skills and subject areas were presented as follows:

Spelling - The method used to teach and to test spelling achievement was the method currently used at the State University of Iowa's Elementary School. Using this method the students were given spelling lessons Monday, Wednesday and Friday. Each Monday the students were presented twenty new spelling words. A review of the words was given on Wednesday. On Friday the students took a test over the spelling words. This Friday test score was used for measuring spelling achievement.

In order to insure control of instructional methods in both classes, all spelling instructions to the students were given via a tape recorder.

The spelling words used in the study were taken from The New Iowa Spelling Scale.[1] The words chosen were between the 35 percent to 50 percent level of difficulty for the fifth grade. After the words were chosen they were placed in groups of twenty for each lesson by means of a table of random numbers. In order to insure the clarity of the tape recordings, to test the word list, and the validity of the method of instruction the first three weeks lessons were first used in the State University of Iowa's Elementary School in the spring of 1965. These tests were conducted with fourth grade pupils.

A week by week spelling list of the words used in this study is presented in Appendix B of this report.

Handwriting - The handwriting system used for this study was the Zaner-Blozer system. This system was chosen since it was the method in which the students had previously received instruction in the Saydel School. Handwriting was taught twenty minutes daily during a four week period of the study, September 13 through October 8. Using the Friday handwriting work, each student was given a handwriting score. All handwriting was evaluated using Feldt's suggestions as stated in "The Reliability of Measures of Handwriting Quality."[2]

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[1] Harry A. Greene, The New Iowa Spelling Scale, State University of Iowa, 1954.

A copy of the handwriting materials used in the study is presented in Appendix C of this report.

Accuracy - Accuracy was measured through the use of ten-key adding machines. The machines used for this study were hand operated Monroe ten-key adding machines. A representative from the Monroe Company gave an oral demonstration lesson on the proper use of the ten-key adding machine to both the control group and the experimental group.

Arithmetic problems were given to the students on teacher prepared work sheets using the ten-key adding machine. By using the adding machines it was possible to compare the students' accuracy in punching keys by comparing each student's adding machine tape with the problem on the worksheet.

Students worked on this accuracy skill two periods a week, Tuesday and Thursday, for exactly fifteen minutes each period during the course of the study. For measuring purposes, the first lesson of each week was considered a practice lesson and the second lesson was scored for errors.

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[2] Leonard S. Feldt, "The Reliability of Measures of Handwriting," Journal of Educational Psychology, Vol. 53, No. 6, 1962, pp. 288-292.

A copy of the worksheets used in measuring students' accuracy is presented in Appendix D of this report.

Mathematics - For the purpose of this study students' skill in mathematics was measured by working arithmetic problems. Arithmetic problems of the type usually used for student drill were used.

The problems were presented to the students on individual worksheets. The students simply worked the problems and wrote their answers on the worksheet. The students worked on these mathematical skills three periods a week for exactly fifteen minutes each period. The days chosen for this subject were Monday, Wednesday and Friday. The student's score was computed by counting the number of correct answers on the Friday worksheet.

A copy of the worksheets used for measuring students skills in mathematics is presented in Appendix E of this report.

Science - All science used in this study was taught by units using programed learning materials. The programed materials used were produced by Cornet Learning Films and were the units "How Scientists Think and Work"[3] and "Your

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[3] _____, *The Way a Scientist Thinks*, Cornet Instructional Films, Chicago 1, Illinois, 1964.

Heart and Circulatory System."[4] The students were permitted to answer the programed materials by writing the correct answer in the blank provided.

Although a time limit was not rigidly fixed because of the nature of the programed materials, approximately twenty-five minutes was spent three times a week on the programed science materials. The students used their science programed materials on Monday, Wednesday and Friday. Each student's score was derived by counting the number of correct responses on the Friday lesson.

It was noticed both by the regular classroom teachers and by the special teacher that some of the students would look ahead at the answers in the programed book before filling in the blank. In order to insure this could not be done, the Friday lesson was given to the students on a mimeographed copy of the lesson.

Teachers

Regular classroom teachers employed by the Saydel Schools were used to teach the regular classroom program. The skills and subject areas used in this study, however, were taught by a special teacher. This special teacher was a fully certified Iowa elementary teacher. This special teacher formerly taught third grade in the Johnston Public Schools.

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[4] ____, *Your Heart and Circulation*, Cornet Instructional Films, Chicago 1, Illinois, 1964.

The regular classroom teachers were assigned to the control group and the experimental group by the Principal of the Norwoodville Elementary School. The special teacher taught all the learning tasks to both the students in the controlled ideal thermal environment classroom and those in the deviate thermal environment classroom. The special teacher was selected by the researcher and the Superintendent of Schools of the Saydel School District. This teacher was repeatedly told of the necessity to be consistent in teaching both groups. All learning tasks that were measured in this study were taught to both groups of students by the same teacher and in the same way.

Time of Day

Each week the special teacher rotated the time of day each skill and subject area was taught. This was done in order that each skill and subject area would be taught to both the control group and the experimental group at the same time of day. For example, if spelling was taught at 10:00 a.m. in the control group and at 10:30 a.m. in the experimental group, the following week the experimental group would have spelling at 10:00 a.m. and the control group at 10:30 a.m.

Table V lists the date and time each of the skills and subject areas were taught to the two groups.

Measures of Achievement

The students' achievement scores were kept during the entire course of the study. The method used to determine students' raw scores was explained previously under the section entitled Skill and Subject Areas of this chapter.

Analysis of Data

This study was concerned simply with the question: o students attending school for a given time period, under a controlled thermal environment that is considered ideal, do better, on the whole, than students who attend for the same period of time under a controlled thermal environment that deviates quite markedly from the ideal? The statistical null hypothesis that was tested in an attempt to answer this question was: the achievement means for a given skill or subject area are the same for both of these treatment

TABLE V

DATE AND TIME EACH SKILL AND SUBJECT AREA TAUGHT IN RESEARCH SCHOOL

Date	Spelling		Handwriting		Accuracy		Math.		Science	
	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.
[illegible]-7					[illegible]	6				
[illegible]-8	5	[illegible]					3	4	[illegible]	
[illegible]					3*	4*				
[illegible]	5*	6*					3*	4*	[illegible]	[illegible]*
[illegible]	6	5	2	[illegible]			[illegible]	[illegible]		7
[illegible]			2	[illegible]	[illegible]	3				
[illegible]	[illegible]	5	2	[illegible]			4	3		7
[illegible]			2		[illegible]*	3*				
[illegible]-17	6*	5*	2*	[illegible]*			4*	3*	[illegible]*	7*
[illegible]	5	6		2						
[illegible]				2	3	[illegible]				
[illegible]	5	6	[illegible]	2			3	4	[illegible]	[illegible]
[illegible]			1	2	3*	4*				
[illegible]	5*	6*	[illegible]*	2*			3*	4*	[illegible]*	[illegible]*
[illegible]-27	6	5	[illegible]	[illegible]			4	3		7
[illegible]			2	[illegible]	[illegible]	3				
[illegible]-29	6	5	2	[illegible]			[illegible]	3		7
[illegible]-30			2	[illegible]	4*	3*				
[illegible]	6*	5*	2*	7*			4*	3*	[illegible]*	7*
[illegible]	5	6	1	2			3	[illegible]	[illegible]	[illegible]
[illegible]			1	2	3	4				
[illegible]	5	6	1	2			3	4		
[illegible]			1	2	3*	4*				
[illegible]	5*	6*	1*	2*			3*	4*	[illegible]*	[illegible]*
[illegible]	6	5					4	3		7
[illegible]					4	3				
[illegible]	6	5					4	3		7
[illegible]					4*	3*				
[illegible]	6*	5*					4*	3*	[illegible]*	7*
[illegible]	5	6					3	4	[illegible]	[illegible]
[illegible]					3	4				
[illegible]	5*	6*					3*	4*	[illegible]*	[illegible]*
[illegible]					3*	4*				
[illegible]	6	5					4	3		7
[illegible]					4	3				
[illegible]	6	5					4	3		7
[illegible]-2[illegible]					4*	3*				
10-29	6*	5*					4*	3*	[illegible]*	7*

TABLE V (Continued)

Date	Spelling		Handwriting		Accuracy		Math.		Science	
	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.	Exp.	Cont.
11-1	5	6					3	4	7	8
11-2					3	4				
11-3	5	6					3	4	7	8
11-4					3*	4*				
11-5	5*	6*					3*	4*	7*	8*

* Score used for analysis

Time of Day Key

1: 10:00-10:20 a.m.
2: 10:30-10:50 a.m.
3: 11:00-11:15 a.m.
4: 11:30-11:45 a.m.
5: 12:30-12:50 p.m.
6: 1:00- 1:20 p.m.
7: 1:30- 1:50 p.m.
8: 2:00- 2:20 p.m.

populations.

An analysis was carried out using the last week's score collected in each skill and subject area in an effort to assess possible differences between the two treatment groups. In addition, each group was subdivided into a low ability level and into a high ability level, using the intelligence test scores, in order to test for possible interaction effects - - i.e., treatment x levels. The statistical test used for this analysis was an analysis of variance (Lindquist Type I).[5]

A second analysis was made in an effort to assess possible dissimilarities between the progress (learning) curve for the two treatment groups. This test was based on performance scores collected weekly over the entire eight week and four day time period; the time period for handwriting was four weeks. There were nine scores in spelling, science, accuracy, and mathematics. Since the subjects in the two samples have been matched or paired, a treatment (thermal condition) by week analysis of variance was used to test for possible differences not only in the overall level of the two learning curves, but more particularly in their slopes or patterns - - i.e., particularly to test for possible interaction between treatment groups and trial weekly performances. As in the second analysis, the treatment groups were subdivided into a low ability level and into a high ability level in order to test for possible interaction effects - - i.e., trials x treatment x levels. The statistical test used for this analysis was an analysis of variance (Lindquist Type VI).[6]

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[5] E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education, Houghton Mifflin Company, Boston, 1956, pp. 267-273.

Level of Significance

A level of significance had to be chosen that took into account the consequences of rejecting a true hypothesis and that of retaining a false hypothesis. Rejecting a true hypothesis is called a Type I Error; retaining a false hypothesis is called a Type II Error. Setting a very high level of significance would control a Type I Error. However, by setting a very high level of significance a Type II Error is more likely to occur. Therefore, in each experiment the level of significance must be set realizing the effects of both a Type I Error and a Type II Error.

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[6] *Ibid.*, pp. 292-297.

The results of making a Type II Error in this study does not appear to be as serious as making a Type I Error. A .01 level of significance is usually considered a high level of control over a Type I Error. A .10 level of significance is rarely used in educational research. As a compromise between the two levels, above a .05 level of significance in this study was used to test all hypotheses.

CHAPTER

ANALYSIS OF DATA

The purpose of this chapter is to analyze the data collected during the study. The data collected were the scores of the students on the various skills and subject areas. The data were analyzed for each of the skills and subject areas separately. These skills and subject areas were spelling, handwriting, accuracy, mathematics and science. An analysis was made to test the hypothesis: there is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment.

Treatment and Data

With the exception of handwriting, nine achievement scores were collected in each skill and subject area. Four handwriting scores were collected. An achievement score was collected weekly for each student in each of the skills and subject areas. The mean score for each group is presented in Table VI.

It can be observed from Table VI there were differences in the means between the experimental group and the

TABLE VI

GROUP MEANS IN EACH SELECTED SKILL AND SUBJECT AREA FOR EACH WEEK

		Week								
Subject	Group	1	2	3	4	5	6	7	8	9
Spelling	Exp.	10.0	12.5	14.0	13.8	14.1	15.8	14.2	15.0	16.0
	Cont.	9.9	13.7	13.6	14.3	13.8	15.8	13.9	15.5	15.6
Handwriting	Exp.	74.0	74.5	74.0	74.6					
	Cont.	73.5	73.0	73.9	74.1					
Accuracy	Exp.	14.7	12.3	16.1	17.0	16.7	19.8	17.0	17.2	20.3
	Cont.	12.5	10.3	18.1	17.0	17.8	17.3	18.2	19.0	20.4
Mathematics	Exp.	30.0	26.0	23.3	23.7	19.7	19.7	25.1	17.5	24.4
	Cont.	27.4	24.9	23.4	24.0	17.2	22.6	23.9	17.2	25.4
Science	Exp.	14.4	11.0	16.0	16.8	13.0	12.2	18.7	20.6	18.2
	Cont.	11.4	11.5	15.3	15.7	12.2	12.9	18.2	22.2	16.0

control group. However, in order to test the hypothesis, it was necessary to examine these differences more closely. Analysis of variance procedures were used to statistically test the differences between the two groups.

As stated in the previous chapter, these differences were examined using two procedures. The first procedure required the test scores made by children on tests in the last week, in each skill and subject area. The difference in means between the experimental group and the control group was tested using the Analysis of Variance-Type I procedure.

A second analysis was used in an effort to assess possible dissimilarities between the progress (learning) curve for the two groups. This test was based on scores collected weekly over the entire time period. Since the students in the two groups had been matched, a treatment by week by subject analysis of variance procedure was used to test for possible differences not only in the overall level of the two learning groups, but more particularly in their curve, i.e., particularly to test for possible interaction between the two groups. The test used for this analysis was the Analysis of Variance - Type VI procedure.

In each analysis both treatment groups were divided into a high and low ability level using the criteria previously stated.

Analysis of Spelling Scores

Analysis of Variance by Type I Design

The means of the scores collected on the last spelling list are shown in Table VII. The analysis of variance summary of these data is presented in Table VIIa.

From Table VIIa it can be observed that the difference in means between the two ability levels was not significant. The difference in means between the two treatment groups was also not significant.

The interaction effect between treatments and levels is shown graphically in Figure 3. This interaction was not significant.

Analysis of Variance by Type VI Design

The performance of the students in all the weekly spelling trials is reported in Table VIII. Table VIIIa is the analysis of variance summary for the spelling scores for all weekly trials. The difference in the mean scores for the two groups was not significant. The difference in means for the ability levels was also not significant.

TABLE VII

GROUP MEANS FOR SPELLING SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Means
Exp.	17.2	14.7	16.0
Cont.	16.6	14.5	15.6
Means	16.9	14.6	15.8

TABLE VIIa

ANALYSIS OF VARIANCE SUMMARY SPELLING SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	29.7965		
Levels	1	56.8180	1.9974	1,20
error (b)	20	28.4455		
Within S	22	24.0000		
Treat.	1	1.4545	0.0553	1,20
Treat. x Levels	1	0.3638	0.0138	1,20
error (w)	20	26.3091		
Total	43			

$F_{05} = 4.35$ df=1,20

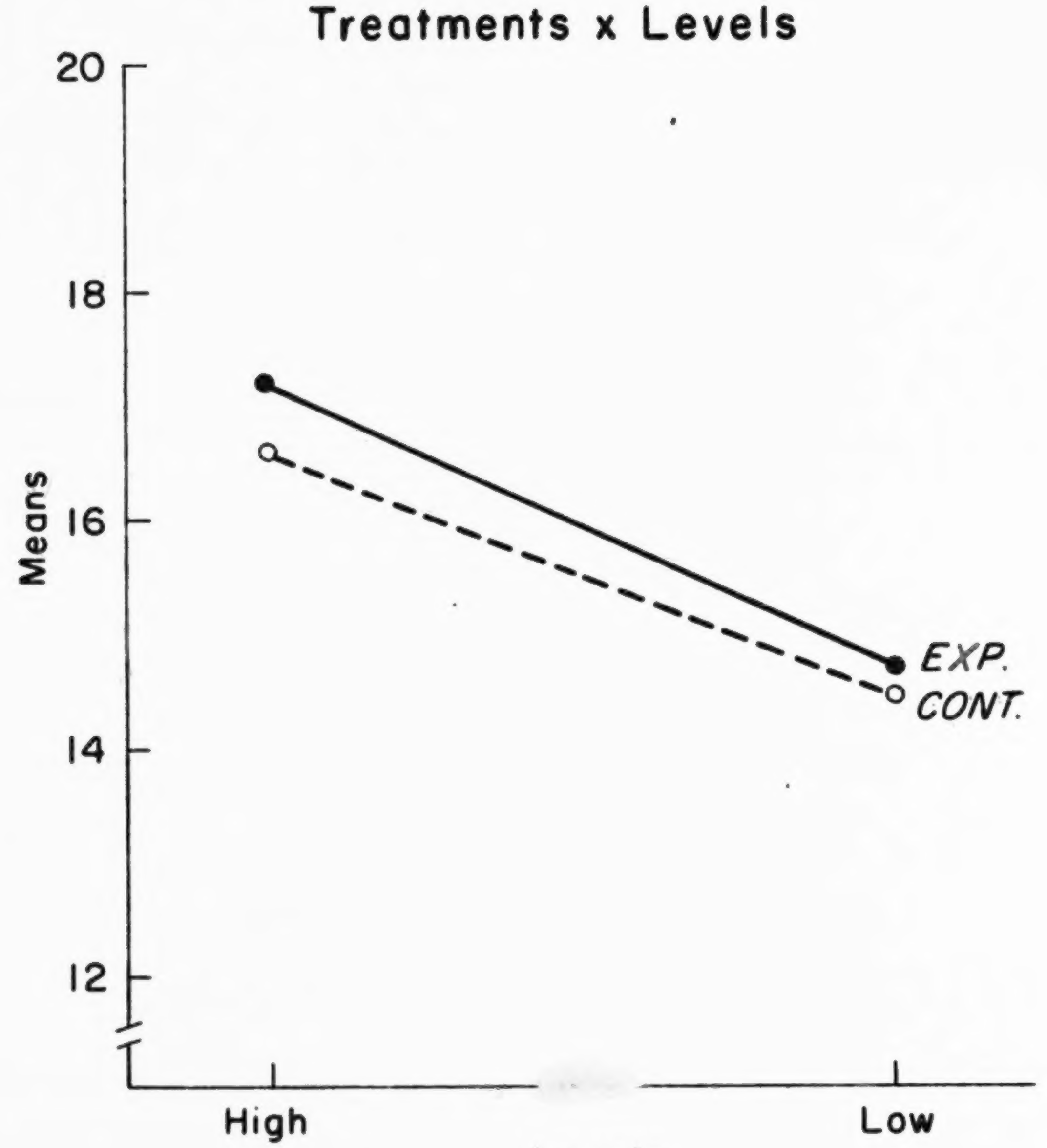

Figure 3

INTERACTION FOR SPELLING SCORES - LAST WEEK ONLY

TABLE VIII

GROUP MEANS FOR SPELLING SCORES – ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	12.2	13.5	15.5	15.5	15.5	17.2	15.9	16.3	17.2	15.4
Cont.	12.2	14.7	15.3	15.6	14.5	16.9	14.9	16.7	16.6	15.3
Means	12.2	14.1	15.4	15.6	15.0	17.0	15.4	16.5	16.9	15.4

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	7.8	11.5	12.5	12.0	12.6	14.5	12.5	13.7	14.7	12.4
Cont.	7.5	12.6	11.9	12.9	13.1	14.7	12.9	14.3	14.5	12.7
Means	7.7	12.1	12.2	12.5	12.9	14.6	12.7	14.0	14.6	12.6

TABLE VIII (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	10.0	12.5	14.0	13.8	14.1	15.8	14.2	15.0	16.0	13.9
Cont.	9.9	13.7	13.6	14.3	13.8	15.8	13.9	15.5	15.6	14.0

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	15.4	12.4	13.9
Cont.	15.3	12.7	14.0

TABLE VIII

ANALYSIS OF VARIANCE SUMMARY
SPELLING SCORES - ALL NINE WEEKS

Source	df	ms	F	(df)
Between S	21	273.1674		
Levels	1	766.6609	3.0853	1,20
error (b)	20	248.4322		
Within S	374	22.7167		
Trials	8	139.6665		
Treatment	1	0.5883	0.0020	1,20
Treat. x Trials	8	3.0339	0.6172	8,160
Trials x Levels	8	6.3619		
Treat. x Levels	1	5.1123	0.0178	1,20
Treat. x Trials x Levels	8	1.2499	0.2543	8,160
Error (w)	340	21.4483		
Error_1(w)	160	4.7080		
Error_2(w)	20	287.4520		
Error_3(w)	160	4.9157		
Totals	395			

$F_{05} = 4.35$ df=1,20 *F Significant

$F_{05} = 2.00$ df=8,160

The interaction effects examined were (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels. These interaction effects are illustrated in Figure 4. Of these interactions, none were significant.

Analysis of Handwriting Scores

Analysis of Variance by Type I Design

The means for the last handwriting trial are shown in Table IX. Table IXa contains the analysis of variance summary for the last trial handwriting scores shown in Table IX. The difference in means for the two ability levels and for the two groups were not significant.

The interaction effect between treatments and levels on this last handwriting trial was not significant. The interaction effect is presented graphically in Figure 5.

Analysis of Variance by Type VI Design

The means for the groups by levels for all handwriting trials are presented in Table X. Table Xa, the analysis of variance summary for all trials, shows that the difference between the groups was not statistically significant.

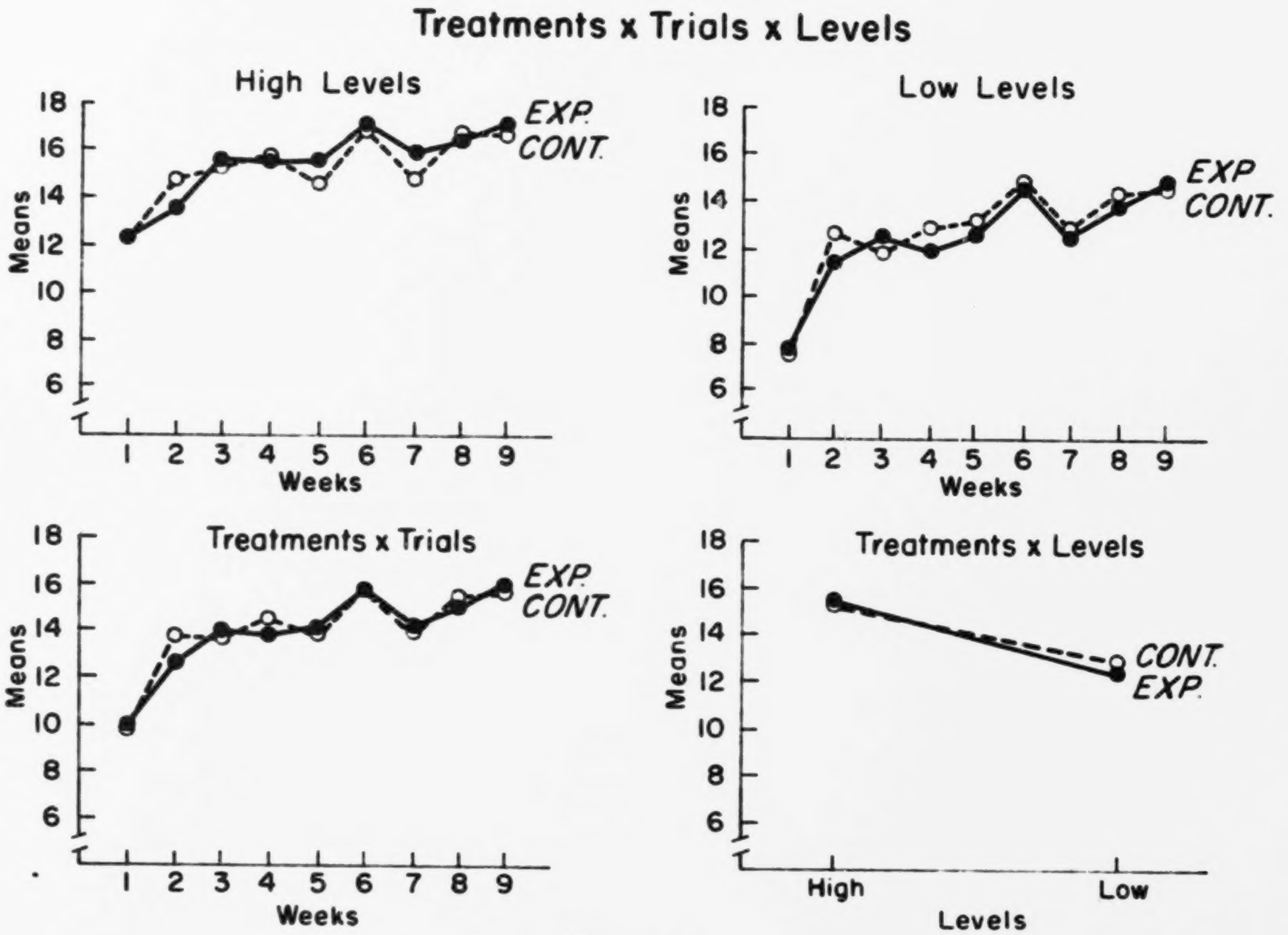

Figure 4

INTERACTION FOR SPELLING SCORES-ALL NINE WEEKS

TABLE IX

GROUP MEANS FOR HANDWRITING SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Means
Exp.	76.5	72.8	74.6
Cont.	74.9	73.3	74.1
Means	75.7	73.0	74.4

TABLE IXa

ANALYSIS OF VARIANCE SUMMARY
HANDWRITING SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	20.8183		
Levels	1	76.4531	4.2388	1,20
error (b)	20	18.0365		
Within S	22	28.9545		
Treat.	1	3.2715	0.1051	1,20
Treat. x Levels	1	11.0019	0.3533	1,20
error (w)	20	31.1363		
Total	43			

$F_{05} = 4.35$ df=1,20 *F Significant

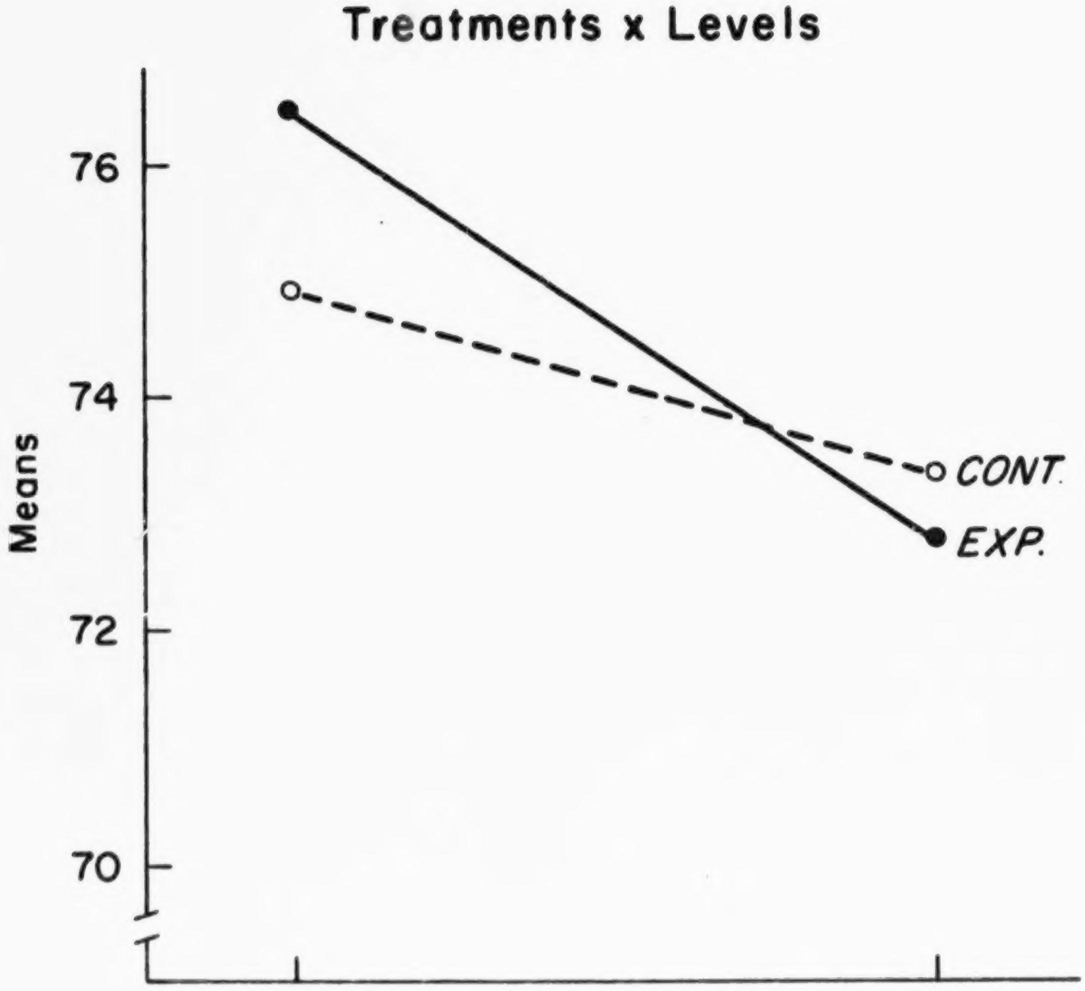

Figure 5

INTERACTION FOR HANDWRITING SCORES - LAST WEEK ONLY

TABLE X

GROUP MEANS FOR HANDWRITING SCORES - ALL FOUR WEEK
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	75.0	75.1	75.4	76.5	75.7
Cont.	74.5	74.7	75.1	74.5	74.5
Means	75.0	75.4	75.2	75.7	75.3

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	73.0	72.9	72.5	72.6	[illegible]
Cont.	72.2	71.2	72.0	70.5	72.3
Means	72.5	72.0	72.3	71.5	[illegible]

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	74.0	74.5	74.0	74.5	74.3
Cont.	73.5	73.0	73.9	74.1	73.6

TABLE X (Continued)

Treatments X Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	75.7	72.8	74.3
Cont.	74.9	72.3	73.6

TABLE Xa

ANALYSIS OF VARIANCE SUMMARY
HANDWRITING SCORES - ALL FOUR WEEKS

Source	df	ms	F	(df)
Between S	21	48.9021		
Levels	1	332.7578	9.5870*	1,20
error (b)	20	34.7094		
Within S	154	16.5357		
Trials	3	3.7213		
Treatment	1	19.1172	0.1955	1,20
Treat. x Trials	3	4.2604	0.9393	2,60
Trials x Levels	3	2.0130		
Treat. x Levels	1	1.0937	0.0112	1,20
Treat. x Trials x Levels	3	4.0286	0.8882	3,60
Error (w)	140	17.7444		
$Error_1$(w)	60	4.2716		
$Error_2$(w)	20	97.7894		
$Error_3$(w)	60	4.5355		
Totals	175			

$F_{05} = 4.35$ df=1,20 *F Significant

$F_{05} = 2.76$ df=3,60

The mean for the high ability level groups for handwriting was 75.3 and the mean for the low ability level groups was 72.6. This difference between levels was statistically significant at the .05 level (F=9.5870).

None of the interactions were significant. The curves of the interactions (1) treatments x trials x levels, (2) treatments x trials, and (3) treatments x levels are shown in Figure 6.

Analysis of Accuracy Scores

Analysis of Variance by Type I Design

The mean scores for the last accuracy trial are reported in Table XI. Table XIa contains the analysis of variance summary for the scores on the last trial.

The difference in mean scores for the two groups was not significant. The difference in mean scores for the two ability levels was also not significant.

The interaction of treatments x levels was examined. The analysis of variance summary table shows this interaction to be not significant. This interaction is illustrated in Figure 7.

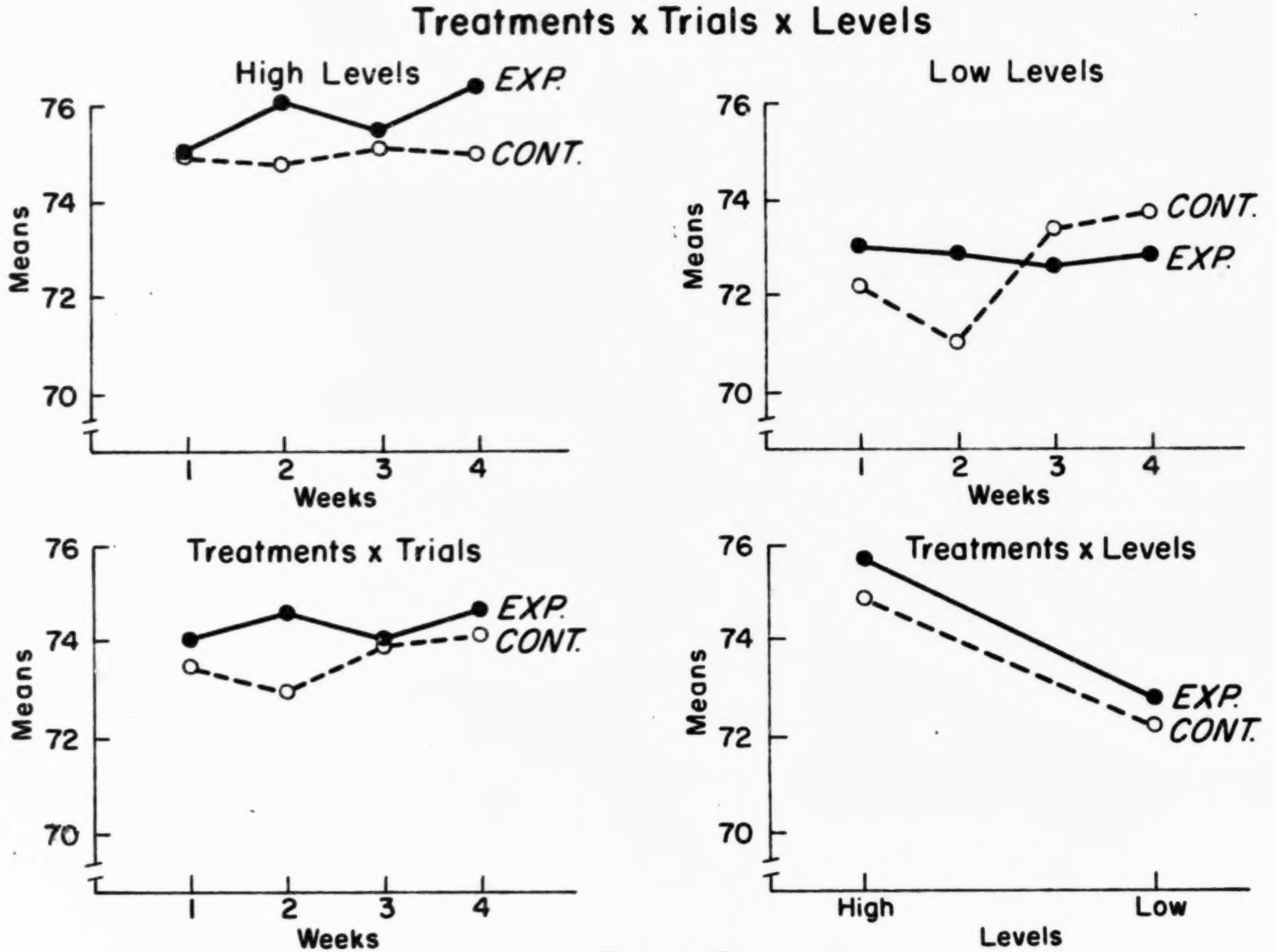

Figure 6

INTERACTION FOR HANDWRITING SCORES - ALL FOUR WEEKS

TABLE XI

GROUP MEANS FOR ACCURACY SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Mean
Exp.	20.5	20.1	20.3
Cont.	22.0	18.8	20.4
Means	21.3	19.5	20.4

TABLE XIa

ANALYSIS OF VARIANCE SUMMARY
ACCURACY SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	32.6753		
Levels	1	36.3636	1.1192	1,20
error (b)	20	32.4909		
Within S	22	47.8182		
Treat.	1	0.0909	0.0018	1,20
Treat. x Levels	1	20.4546	0.3966	1,20
error (w)	20	51.5727		
Total	43			

$F_{.05} = 4.35$ df=1,20 *F Significant

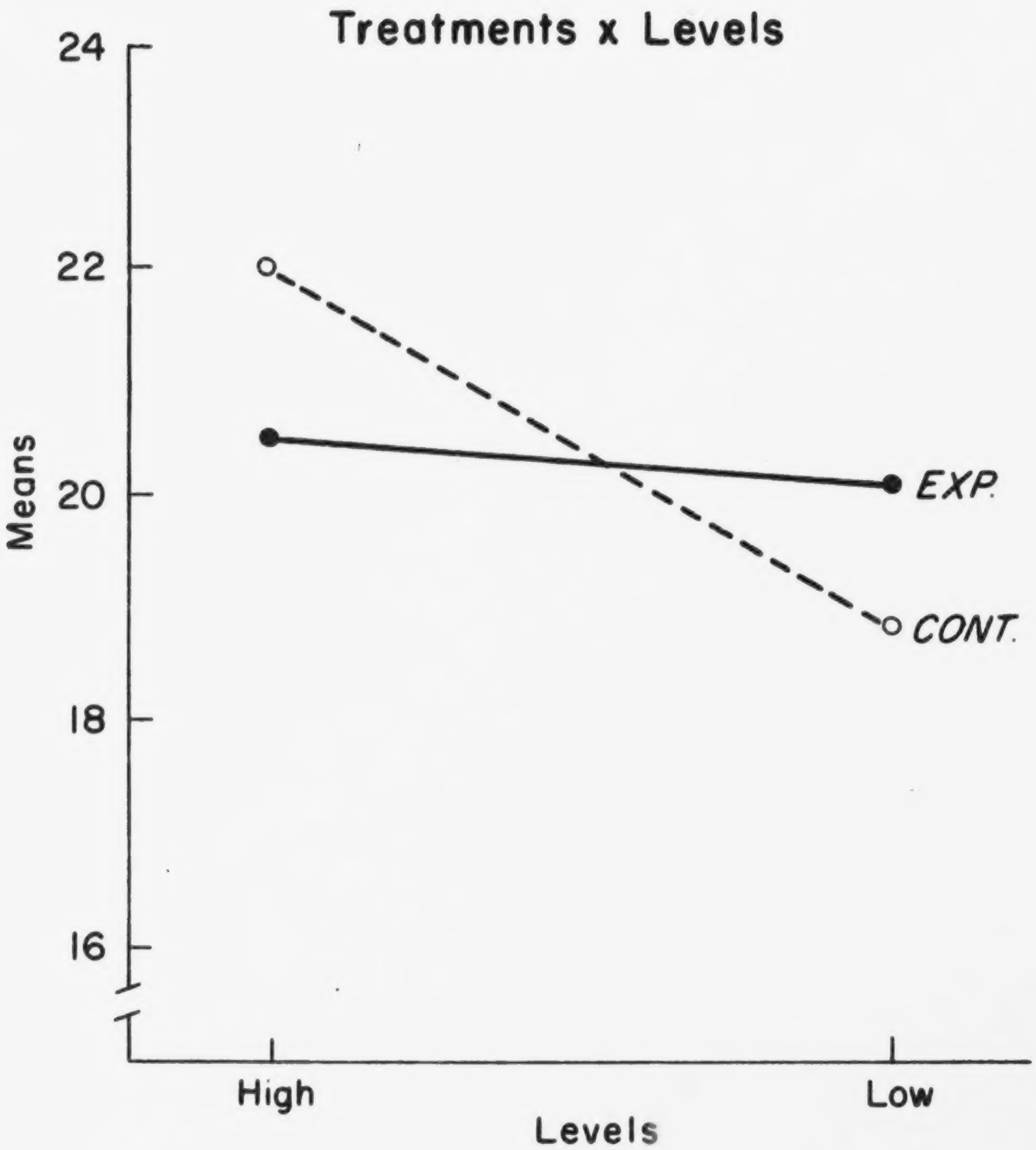

Figure 7

INTERACTION FOR ACCURACY SCORES - LAST WEEK ONLY

Analysis of Variance by Type VI Design

The means of the accuracy scores for all the weekly trials are reported in Table XII. From Table XIIa, which presents the analysis of variance summary for the scores, it can be seen that the difference between the groups was not statistically significant. The difference between ability levels was not significant.

The interaction effects shown in Table XII are presented in Figure 8 in graphic form. Only the interaction of treatments x trials was statistically significant at the .05 level (F=2.0583). The interaction for treatments x trials x levels and for treatments x levels was not significant.

Analysis of Mathematics Scores

Analysis of Variance by Type I Design

The mean scores for the last mathematics trial are reported in Table XIII. The analysis of variance summary is presented in Table XIIIa. The difference in mean scores for the two groups was not significant. The difference in mean scores for the ability levels was significant (F=6.6157). The mean of the high ability level was 27.5 and the mean for

TABLE XII

GROUP MEANS FOR ACCURACY SCORES - ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	16.0	12.9	17.0	16.8	15.0	21.8	17.1	17.2	20.5	17.5
Cont.	12.5	11.2	18.5	16.3	16.6	17.9	20.6	15.8	22.0	17.6
Means	14.2	12.0	17.8	[illegible]	15.8	19.9	18.9	16.5	21.3	17.6

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	13.4	11.7	15.3	17.2	15.4	17.8	16.9	17.3	20.1	16.1
Cont.	12.5	9.4	17.6	15.6	17.0	16.6	15.7	19.1	18.8	15.8
Means	13.0	10.6	16.5	16.4	16.2	17.2	16.3	18.2	19.5	16.0

TABLE XII (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	14.7	12.3	16.1	17.0	16.7	19.8	17.0	17.2	20.3	16.8
Cont.	12.5	10.3	18.1	17.0	17.8	17.3	18.2	19.0	20.4	16.7

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	17.5	16.1	16.8
Cont.	17.6	15.8	16.7

TABLE XIIa

ANALYSIS OF VARIANCE SUMMARY
ACCURACY SCORES - [illegible]

Source	df	ms	F	(df)
Between S	21	[illegible]		
Levels	1	[illegible]	1.1400	1,20
error (b)	20	[illegible]		
Within S	374	[illegible]		
Trials	8	[illegible]		
Treatment	1	[illegible]	[illegible]	1,20
Treat. x Trials	8	[illegible]	[illegible]*	8,160
Trials x Levels	8	[illegible]		
Treat. x Levels	1	[illegible]	[illegible]	1,20
Treat. x Trials x Levels	8	[illegible]	[illegible]	8,160
Error (w)	340	[illegible]		
$Error_1$(w)	160	18.0000		
$Error_2$(w)	20	292.8020		
$Error_3$(w)	160	10.4000		
Totals	395			

$F_{05} = 4.35$ df=1,20 *F Significant
$F_{05} = 2.00$ df=8,160

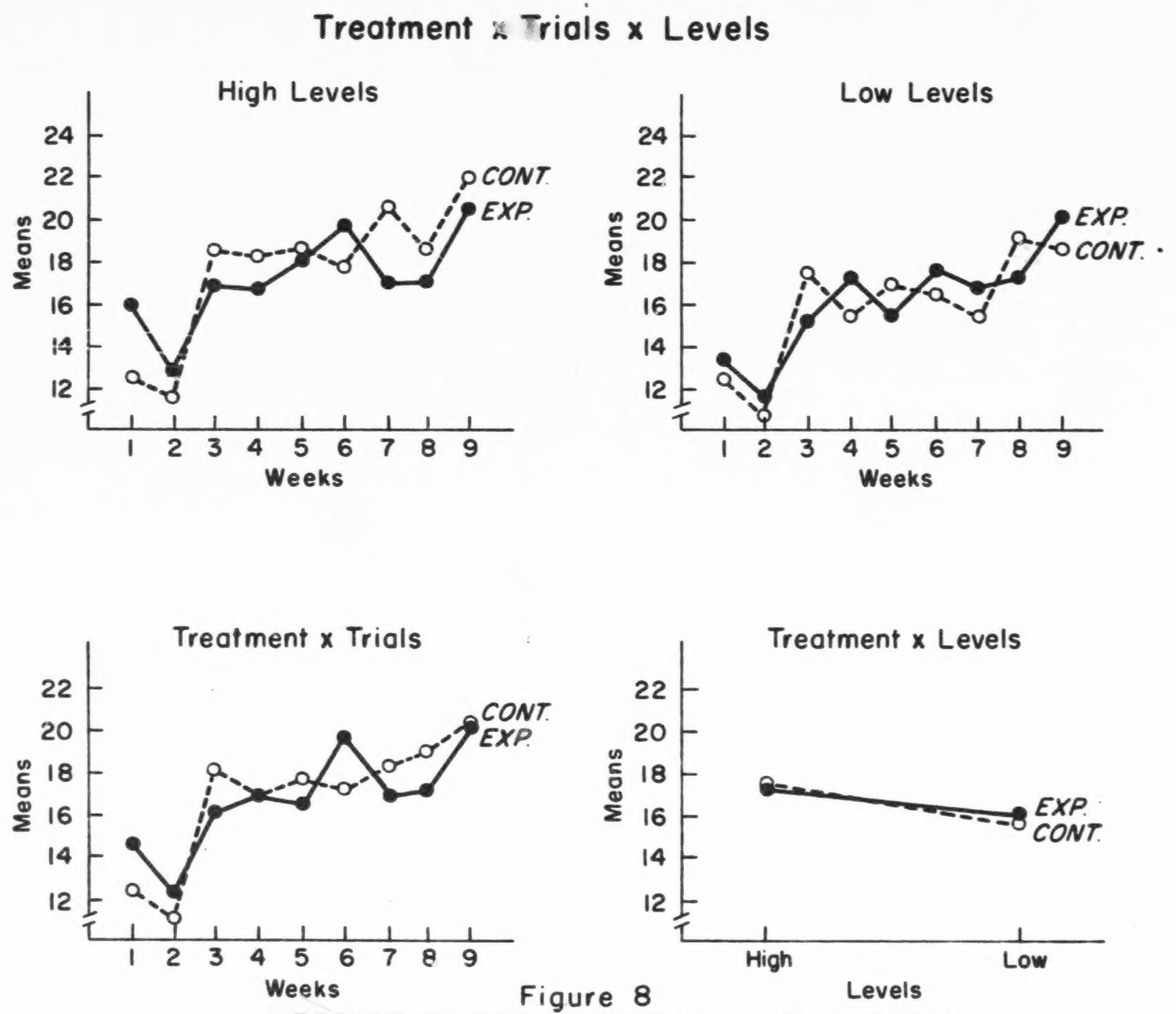

Figure 8
INTERACTION FOR ACCURACY - ALL NINE WEEKS

TABLE XVII

GROUP MEANS FOR MATHEMATICS SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Mean
Exp.	26.8	22.1	24.4
Cont.	28.5	22.4	25.4
Means	27.5	22.2	24.9

TABLE XVIIa

ANALYSIS OF VARIANCE SUMMARY
MATHEMATICS SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	46.4253		
Levels	1	311.[illegible]	8.6107*	1,20
error (b)	20	36.2006		
Within S	22	76.5227		
Treat.	1	12.0227	0.1444	1,20
Treat. x Levels	1	6.5676	0.0789	1,20
error (w)	20	83.245[illegible]		
Total	43			

$F_{05} = 4.35$ df=1,20 *F Significant

the low ability level was 22.2.

The interaction on the last trial of treatments x levels was not significant. This interaction is illustrated graphically in Figure 9.

Analysis of Variance by Type VI Design

Table XIV contains the mean scores of the mathematics trials for all nine weeks. Table XIVa contains the analysis of variance summary of all weekly mathematics scores.

From Table XIVa it can be observed that the difference between groups was not significant.

However, the difference between the high ability level and low ability level was significant (F=14.3488). The mean for the high ability level was 25.8. The mean for the low ability level was 20.4.

Figure 10 illustrates the curves for the interactions. The F values of all the interactions were not significant.

Analysis of Science Scores

Analysis of Variance by Type I Design

The means received in the science test for the last Friday is presented in Table XV. The analysis of variance

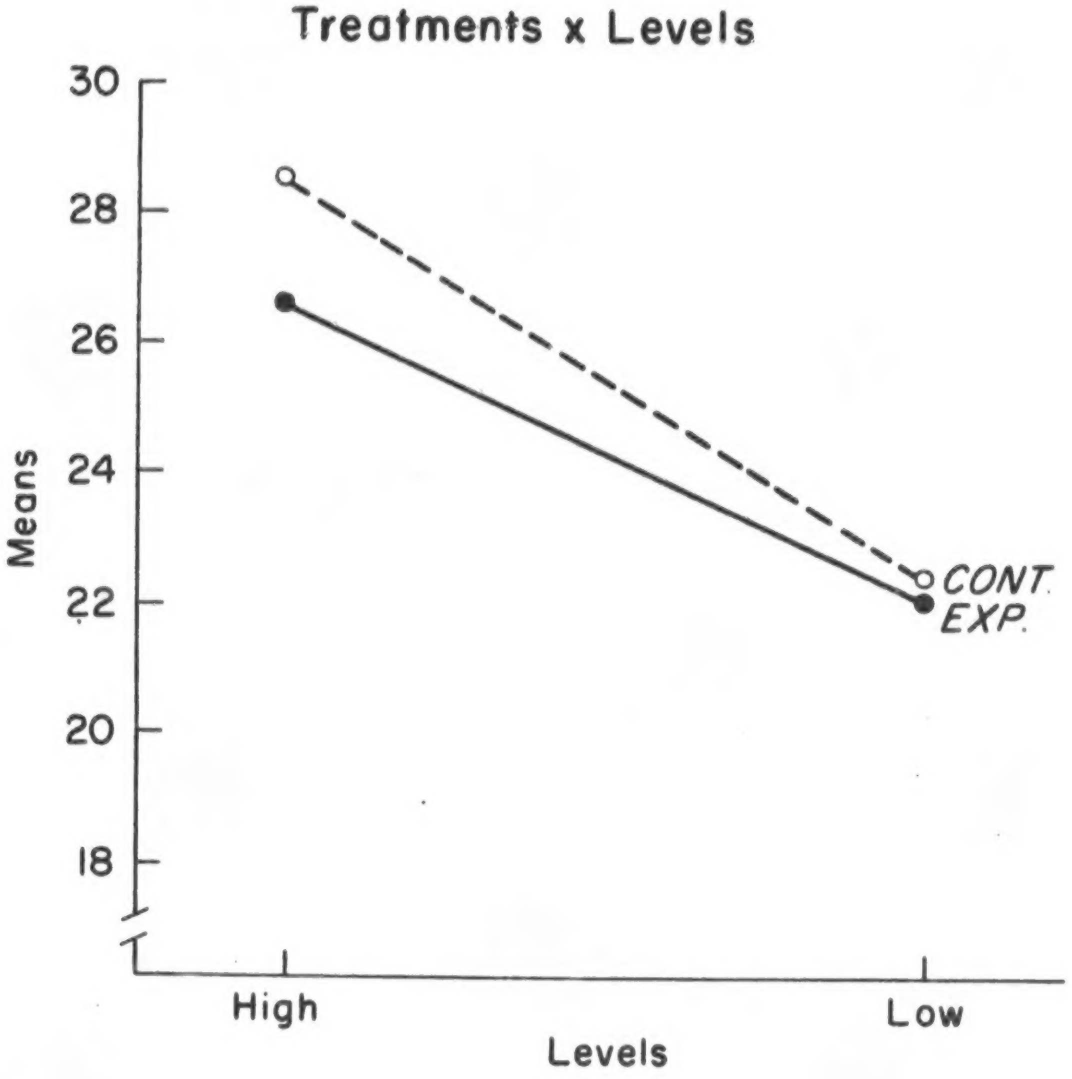

Figure 9

INTERACTION FOR MATHEMATICS SCORES - LAST WEEK ONLY

TABLE XIV

GROUP MEANS FOR MATHEMATICS SCORES - ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Groups (Treat.)					Weeks					Means
	1	2	3	4	5	6	7	8	9	
Exp.	30.0	29.8	26.1	24.4	22.1	21.6	26.8	21.5	26.6	25.4
Cont.	28.7	26.5	27.8	26.3	20.6	27.9	27.2	22.1	28.5	26.2
Means	29.4	28.1	27.0	25.3	21.4	24.8	27.0	21.8	27.5	25.8

Low Levels

Groups (Treat.)					Weeks					Means
	1	2	3	4	5	6	7	8	9	
Exp.	30.0	22.3	20.5	23.1	17.4	17.7	23.4	13.5	22.1	21.1
Cont.	26.1	23.4	18.9	21.8	13.7	17.4	20.6	12.4	22.4	19.6
Means	28.0	22.8	19.7	22.5	15.5	17.5	22.0	12.9	22.2	20.4

TABLE XIV (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	30.0	26.0	23.3	23.7	19.7	19.7	25.1	17.5	24.4	23.3
Cont.	27.4	24.9	23.4	24.0	17.2	22.6	23.9	17.2	25.4	22.9

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	25.4	21.1	23.3
Cont.	26.2	19.6	22.9

TABLE XIVa

ANALYSIS OF VARIANCE SUMMARY
MATHEMATICS SCORES - ALL NINE WEEKS

Source	df	ms	F	(df)
Between S	21	333.8978		
Levels	1	2929.1152	14.3488*	1,20
error (b)	20	204.1369		
Within S	374	55.3594		
Trials	8	557.7099		
Treatment	1	13.4570	0.0332	1,20
Treat. x Trials	8	33.8713	1.4689	8,160
Trials x Levels	8	57.8911		
Treat. x Levels	1	121.1094	0.2986	1,20
Treat. x Trials x Levels	8	23,3455	1.0124	8,160
Error (w)	340	44.6685		
Error$_1$(w)	160	21.1631		
Error$_2$(w)	20	405.5904		
Error$_3$(w)	160	23.0587		
Total	395			

F_{05} = 4.35 df=1,20 *F Significant
F_{05} = 2.00 df=8,160

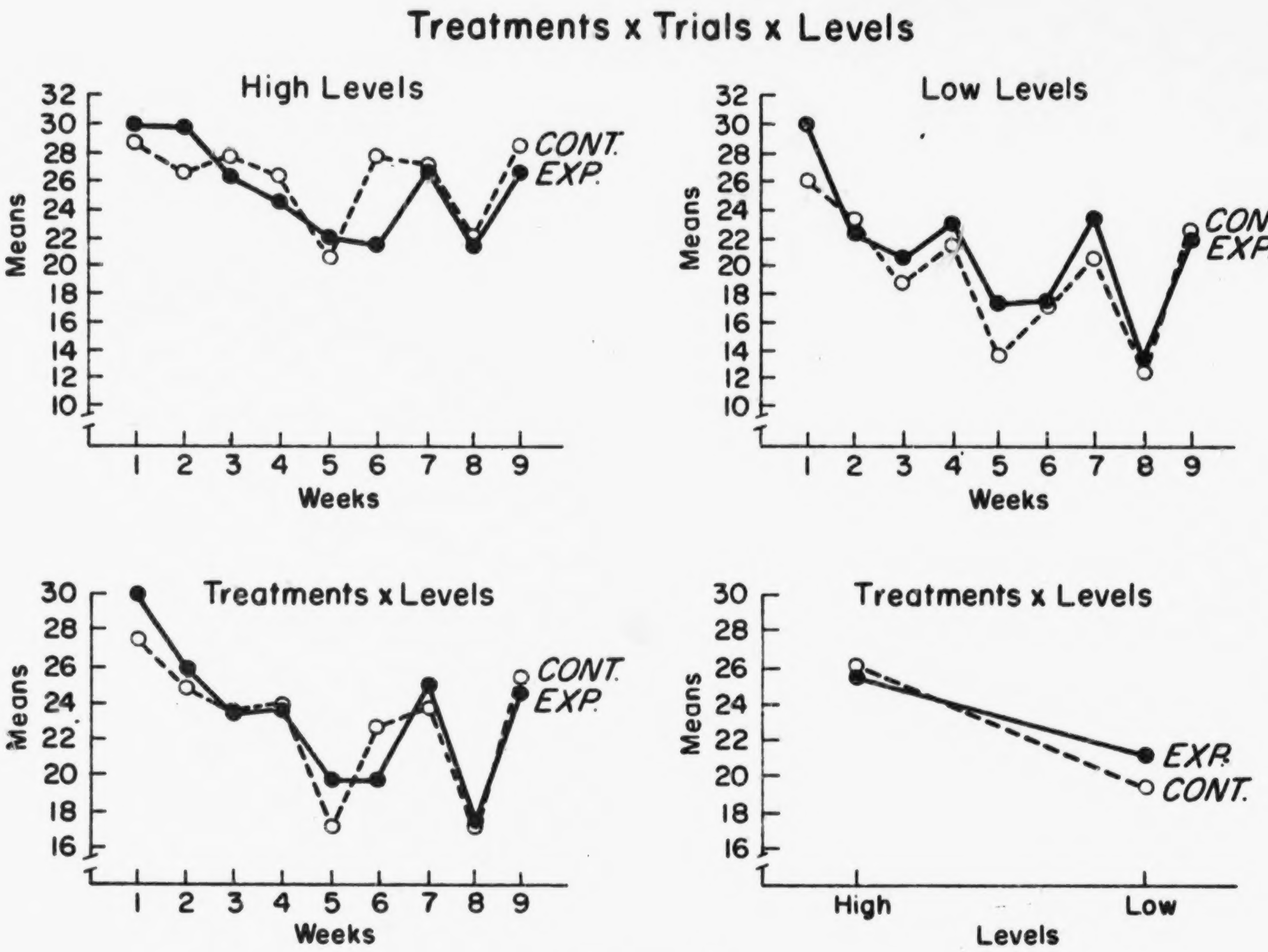

Figure 10
INTERACTION FOR MATHEMATICS SCORES - ALL NINE WEEKS

TABLE XV

GROUP MEANS FOR SCIENCE SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Mean
Exp.	21.8	14.5	18.2
Cont.	16.6	15.4	16.0
Means	19.2	15.0	17.1

TABLE XVa

ANALYSIS OF VARIANCE SUMMARY
SCIENCE SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	80.1732		
Levels	1	200.8181	2.7086	1,20
error (b)	20	74.1409		
Within S	22	84.2727		
Treat.	1	52.3636	0.6151	1,20
Treat. x Levels	1	99.0000	1.1629	1,20
error (w)	20	85.1318		
Total	43			

$F_{05} = 4.35$ df=1,20 *F Significant

summary of the last trial of the science scores is presented in Table XVa. The difference in mean scores between the experimental group and the control group was not significant. The difference in mean scores between the high ability level and the low ability level was also not significant.

The interaction effect of treatments x levels was not statistically significant. This interaction is shown graphically in Figure 11.

Analysis of Variance by Type VI Design

The means of the nine weekly science scores are reported in Table XVI. Table XVIa contains the analysis of variance for the scores on all the weekly science trials. The difference in means between the experimental group and the control group was not statistically significant. Also not significant was the difference between the ability levels.

The F value for the interactions (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels was not significant. The curves of all the weeks, groups, and levels are illustrated in Figure 12.

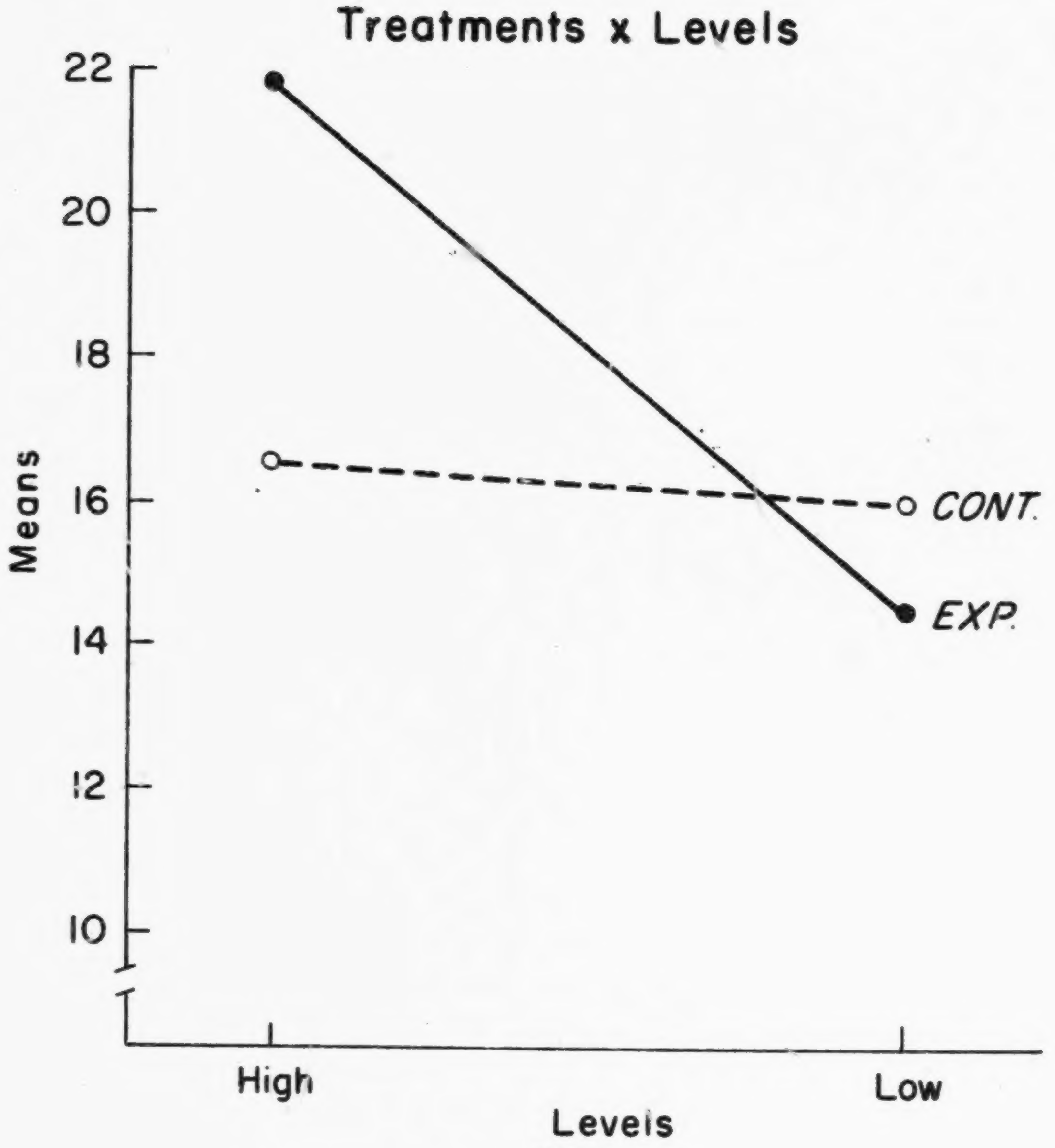

Figure II

INTERACTION FOR SCIENCE SCORES - LAST WEEK ONLY

TABLE XVI

GROUP MEANS FOR SCIENCE SCORES - ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	15.3	12.2	16.7	20.6	15.1	15.8	21.1	24.5	21.8	18.1
Cont.	12.4	12.8	16.8	17.4	13.8	13.5	19.7	23.3	16.6	16.3
Means	13.8	12.5	16.8	19.0	14.5	14.7	20.4	23.9	19.2	17.2

Low Levels

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	13.5	9.9	15.4	13.0	10.8	8.6	16.4	16.6	14.5	13.2
Cont.	10.5	10.3	13.7	14.1	10.5	12.2	16.7	21.1	15.4	13.8
Means	12.0	10.1	14.5	13.5	10.7	10.4	16.5	18.9	15.0	13.5

TABLE XVI (Continued)

Treatments x Trials

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	14.4	11.0	16.0	16.8	13.0	12.2	13.7	20.6	18.2	15.7
Cont.	11.4	11.5	15.3	15.7	12.2	12.9	18.2	22.2	16.0	15.0

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	17.5	16.1	16.8
Cont.	17.6	15.8	16.7

TABLE [illegible]

ANALYSIS OF VARIANCE SUMMARY
SCIENCE SCORES - [illegible] NINE WEEKS

Source	df	ms	F	(df)
Between S	21	471.9075		
Levels	1	1345.7070	3.1426	1,20
error (b)	20	428.2175		
Within S	374	48.7926		
Trials	8	435.6960		
Treatment	1	37.5859	0.0964	1,20
Treat. x Trials	8	21.8525	1.0597*	8,160
Trials x Levels	8	17.5760		
Treat. x Levels	1	155.3125	0.3984	1,20
Treat. x Trials x Levels	8	24.8413	1.2046	8,160
Error (w)	340	40.1642		
$Error_1$(w)	160	15.9956		
$Error_2$(w)	20	389.8549		
$Error_3$(w)	160	20.6215		
Total	395			

F_{05} = 4.35 df=1,20 *F Significant
F_{05} = 2.00 df=8,160

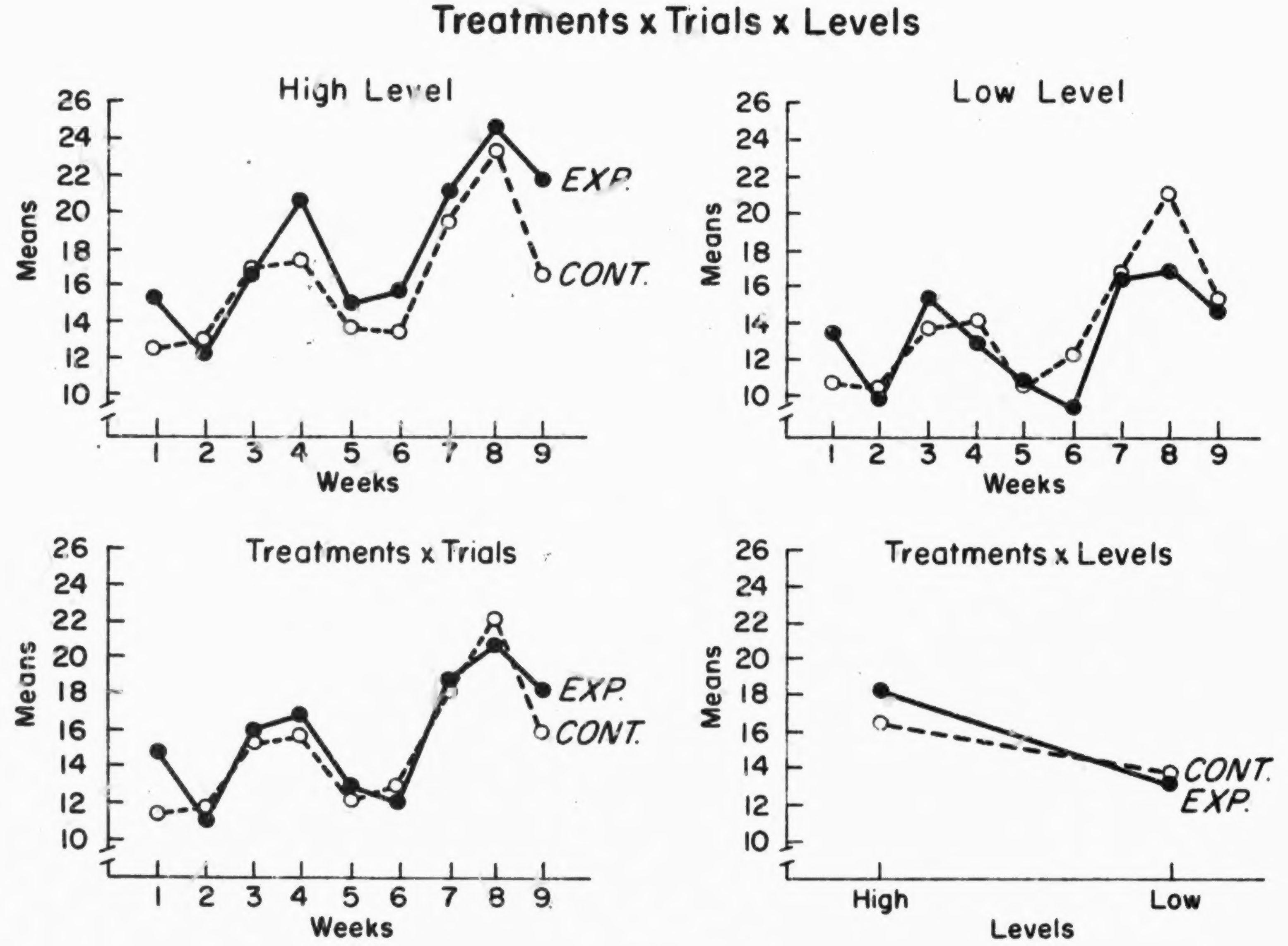

Figure 12

INTERACTION FOR SCIENCE SCORES - ALL NINE WEEKS

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study tested the hypothesis: there is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment. A .05 level of significance was used to test all hypotheses.

Procedures

Through the joint cooperation of the Saydel School District, Saydel, Iowa, the Lennox Industries Inc. and the University of Iowa, the study was conducted using the following procedures:

1. Two matched groups of fifth grade students were chosen from the Saydel School District. Twenty-two matched pairs of students were selected for the two groups. The students were matched by intelligence test scores, achievement test results, sex, age, and family background.

   By the flip of a coin one group was designated to be the experimental group. The second group was designated to be the control group.

   Both the experimental group and the control group were divided into a high ability level and a low ability level on the basis of intelligence test scores. The eleven students having the highest intelligence test scores in each group were considered high ability level and the remaining eleven students in each group were considered the low ability level.

2. The Lennox Industries Inc. furnished a two room school to conduct the study. Both classrooms were identical in all relevent physical aspects. Any desirable thermal environment could be maintained in either classroom.

3. In one classroom a thermal environment that was considered as ideal was maintained. These ideal conditions were established after an extensive review of literature and consulting with authorities in thermal environment control. The students in the experimental group were placed in the ideal thermal environment.

   In the second classroom a thermal environment was maintained that was different than that of the ideal thermal environment. This second classroom thermal environment was called deviate. The students in the control group were placed in the deviate thermal environment.

4. Regular Saydel School teachers taught the students their customary school subjects. A certified and experienced elementary teacher was employed to teach both groups of students in certain selected skills and subject areas. This special teacher taught spelling, handwriting, accuracy, mathematics, and science to the students. All instruction in these areas was presented using an acceptable teaching method.

5. In the selected areas all teaching instruction to both groups of students was identical. The students in both groups spent the same amount of time on each area. In addition, the students performed each task on the same and,

in effect, at the same time of day.

A weekly achievement score was collected from all students in each selected skill and subject area. The achievement score collected was the end of the week's lesson in each area.

6. The students were in the study for an eight week and four day time period. (Approximately nine school weeks).

7. At the end of the nine week period the data on the two groups were statistically analyzed. The statistical analyses used were analysis of variance procedures. The scores of the last week in each area were analyzed using Lindquist - Type I procedures. The scores of all weeks in each area were examined using Lindquist - Type VI procedure.

Summary of the Analyses

Last Trial Summary

A summary of scores collected in the last week is presented in Table XVII. This table contains the group means of the scores for the last week in each skill and subject area and the F value for the difference in the means for the two groups. The ability level means and the F value is included. The F value for the interaction between levels and treatments is also presented in Table XVII. It was observed from this table that there was no statistically significant difference between group means for the last trial results. None of the interactions were

TABLE XVII

SUMMARY OF SCORES FOR THE LAST WEEK, GROUP MEANS AND INTERACTIONS

Skill or Subject	Group Means (Treatment)			Ability Means (Levels)			Interaction (Treat. x Levels)
	Exp.	Cont.	F Value	High	Low	F Value	F Value
Spelling	16.0	15.6	0.0553	16.9	14.6	1.9374	0.0138
Handwriting	74.6	74.1	0.1051	75.7	73.0	4.2382	0.3533
Accuracy	20.3	20.4	0.0018	21.3	19.5	3.1192	0.3966
Mathematics	24.4	25.4	0.1444	27.5	22.2	8.9357*	0.0789
Science	18.2	16.0	0.0151	19.2	15.0	2.7066	1.1629

*F Significant

significant.

The spelling score means for the experimental group and the control group were 16.0 and 15.6, respectively. In handwriting the mean for the experimental group was 74.6 and the mean for the control group was 74.1. On the accuracy skill tests the means were 20.3 and 20.4 for the experimental and control groups, respectively. In mathematics the mean for the control group was above that of the experimental group. The mean for the experimental group was 24.4 and for the control group it was 25.4. In science the mean score for the students in the experimental group was 18.2 and those in the control group achieved a mean of 16.0.

From Table XVII it was seen that the difference in mean scores between the high ability level and the low ability level was significant in mathematics, in favor of the high ability level. The differences in the mean scores between the two ability levels were not significant in the other skills and subjects.

All Trials Summary

The analysis of all trials is presented in Table XVIII. The means were presented for the high and low ability levels and for the experimental and control groups. F

TABLE XVIII

SUMMARY OF ALL WEEKS SCORES, GROUP MEANS AND INTERACTIONS

Skill or Subject	Ability Means (Levels)			Group Means (Treatment)			Interaction F Values		
	High	Low	F Value	Exp.	Cont.	F Value	Treat. x Trials	Treat. x Levels	Treat. x Trials x Levels
Spelling	15.4	12.6	3.0853	13.9	14.0	0.0020	0.6172	0.0178	0.2543
Handwriting	75.3	72.6	9.5870*	74.3	73.6	0.1955	0.9393	0.0112	0.8882
Accuracy	17.6	16.0	1.1465	16.8	16.7	0.0022	2.0599*	0.0124	1.1423
Mathematics	25.8	20.4	14.3488*	23.3	22.9	0.0332	1.4889	0.2986	1.0124
Science	17.2	13.5	3.1426	15.7	15.0	0.0964	1.0597	0.3984	1.2046

*F Significant

values were presented for the differences in means between the two ability levels and for the two groups. The interaction F values for (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels are also given in the table.

The means on all spelling trials were 13.9 for the experimental group and 14.0 for the control group. The mean for the experimental group and the mean for the control group was 74.3 and 73.6, respectively, on all handwriting trials. On all accuracy test trials the mean achieved by the experimental group was 16.8 and 16.7 for the control group. When all trials were considered in mathematics, the mean for the experimental group was 23.3 and the mean for the control group was 22.9. A mean of 15.7 for all trials was achieved by the experimental group in science. The control group achieved a mean of 15.0 for all science trials.

None of the F values for the differences between the means of the two groups were statistically significant.

In two areas statistically significant differences were found between the high ability level and the low ability level. These two areas were handwriting and mathematics. The high ability level students achieved a mean of 75.3 in all handwriting trials while the low ability level students had a mean of 72.6 for the subject. This difference was significant at the .05 level. For all mathematics trials the high ability level students had a mean of 25.8 and the mean for the low ability level students was 20.4. This difference was significant.

The only interaction that was statistically significant was that between treatments and trials in the accuracy tests.

Conclusions

The test conducted was of the null hypothesis: there is no difference between pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment. The results of this study lead to an acceptance of this null hypothesis.

The conclusion reached by this study was that student learning is not affected by attending school in a controlled ideal thermal environment.

Recommendations

At the conclusion of this study, it was evident that measuring the effects of thermal environment on learning had just begun. Using the experience gained in conducting this study the following recommendations are submitted as specific areas in which additional research is needed:

Recommendation No. 1

The next researcher would be well advised to duplicate some of the tasks, skills, and subject areas that were used in previous studies. This would help to confirm or reject the findings of previous studies. It may be found that pupil learning is affected by the thermal environment, but that our measurement instruments are too gross in school subjects to detect the differences.

The findings of this study contradict, to a certain extent, the findings of the first study conducted by Dr. Charles Peccolo. This researcher does not propose that one study is right and the other wrong. A careful examination of the two studies will reveal several dissimilarities in the procedures in the two studies.

Recommendation No. 2

Future studies might prove more valuable if conducted over a longer time period than was used in this research.

All individuals associated with this study realize that research has only begun to scratch the surface in measuring the effects of thermal environment on pupils. Education is a long term experience, and perhaps a nine week time period is too short a period in which to measure the effect of an ideal thermal environment.

Recommendation No. 3

Future studies ought to be conducted jointly with a Department of Home Economics to measure nutritional effects of the thermal environment.

The private catering service observed that they could tell which room had the ideal thermal environment as those students had heartier appetites. (The same caterers had been used in previous studies).

Recommendation No. 4

Future studies should make an attempt to measure the effect of thermal environment on student attitudes toward school.

The teachers involved in this present study noticed that the students in the ideal thermal environment were not as restless as the students in the deviate environment.

Recommendation No. 5

Future research should make a conscious effort to involve a greater number of boys and girls covering a wider range in socio-economic backgrounds.

Forty-four boys and girls were involved in the current study. By chance, these particular students were from a relatively low socio-economic level.

Recommendation No. 6

Future research should be conducted using students from all grade levels.

Recommendation No. 7

Future research might prove valuable if conducted during meteorologically contrasting months of the calendar year. (In this study heated air was never added to the ideal classroom while the younsters were in the classroom).

Recommendation No. 8

Further research should be conducted to examine the effect of an ideal thermal environment on teacher attitudes. (Students involved in this study filled out a form indicating their level of comfort five times daily. This data will be analyzed in a separate report).

Recommendation No. 9

Future studies should be continued in order to determine if there is a comfort zone at which students do learn best.

Recommendation No. 10

Future research ought to be conducted to determine if, after an intensive period of physical activity, an ideal thermal environment shortens the time necessary for a return to usual classroom routine of the students.

APPENDICES

APPENDIX A

HOME CLASSROOM TEMPERATURE AND HUMIDITY RECORDINGS

	Time													
	0900		1000		1100		1200		1300		1400		1500	
Date	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Sept. 7	76	69	78	74	79	73	77	71	76	72	77	69	76	68
Sept. 8	74	68	76	71	77	69	73	68	79	71	79	74	78	77
Sept. 9	79	81	82	76	83	73	84	70	86	64	86	63	88	64
Sept.10	78	56	79	55	80	57	83	58	86	58	86	56	86	56
Sept.13	76	75	76	75	78	72	79	73	79	76	80	66	81	65
Sept.14	76	65	76	66	77	70	77	70	77	71	77	69	78	70
Sept.15	62	53	73	57	74	55	76	55	77	50	77	47	77	54
Sept.16	69	61	70	62	70	62	70	63	70	66	70	60	70	68
Sept.17	73	68	73	62	75	62	76	64	76	62	77	60	78	55
Sept.20	75	71	74	68	74	69	75	6	75	65	75	66	77	65
Sept.21	73	74	72	68	72	64	72	56	72	52	70	47	72	47
Sept.22	72	55	74	54	75	54	77	[illegible]	78	52	77	49	78	50
Sept.23	.69	50	70	52	73	50	76	43	80	41	85	40	85	43
Sept.24	84	37	85	37	86	37	86	37	88	36	88	37	88	37
Sept.27	72	48	74	47	75	46	76	46	76	47	77	46	78	47
Sept.28	78	55	77	58	79	58	82	55	84	55	85	57	85	55
Sept.29	78	56	80	63	81	61	83	[illegible]	84	59	86	58	86	54
Sept.30	75	55	75	56	74	56	74	52	74	50	74	54	74	56
Oct. 1	75	44	76	49	78	49	80	45	82	41	84	47	84	43
Oct. 4	78	44	82	41	80	41	82	41	84	40	85	40	85	41
Oct. 5	78	40	81	38	82	38	84	40	85	44	86	44	86	42
Oct. 6	75	43	76	44	74	46	76	43	79	45	80	49	80	42
Oct. 7	77	38	79	41	82	38	83	37	82	33	81	40	79	30
Oct. 8	78	35	79	37	81	37	83	36	85	32	85	37	86	30
Oct. 11	80	33	82	34	83	30	85	29	87	24	88	31	88	31
Oct. 12	77	32	78	30	80	29	82	28	84	27	84	28	84	28
Oct. 13	77	33	80	31	81	30	84	30	85	30	87	30	86	29
Oct. 14	76	44	81	49	79	51	78	54	81	56	81	59	80	59
Oct. 15	82	50	80	54	80	56	82	58	85	57	88	56	88	55
Oct. 18	82	56	85	55	88	51	90	46	91	43	92	41	91	39
Oct. 19	79	52	79	56	80	57	79	57	79	58	78	62	78	61
Oct. 20	80	54	78	54	78	54	78	53	78	51	77	54	76	55
Oct. 21	78	51	79	50	78	48	78	47	77	47	76	51	76	52
Oct. 25	75	36	84	36	88	36	89	38	90	37	91	39	91	40
Oct. 26	79	35	86	36	92	34	88	34	86	31	87	37	85	38
Oct. 27	82	34	87	33	90	31	91	33	91	32	91	31	90	29

APPENDIX A (Continued)

	Time													
	0900		1000		1100		1200		1300		1400		1500	
Date	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Oct. 28	78	29	84	30	90	27	91	27	91	22	91	24	91	25
Oct. 29	78	26	80	27	84	27	87	25	86	25	85	28	85	30
Nov. 1	78	31	83	30	89	25	92	23	90	21	91	22	87	21
Nov. 2	81	32	86	35	88	35	90	35	92	34	88	34	88	32
Nov. 3	81	36	82	37	84	38	83	38	84	38	84	40	86	40
Nov. 4	78	31	82	30	85	26	88	26	88	24	88	25	89	26
Nov. 5	76	31	81	32	85	33	86	38	88	41	89	43	88	44

APPENDIX B

SPELLING LESSONS

FIRST WEEK

1. alley
2. choose
3. naked
4. stare
5. escape
6. happiest
7. terms
8. swear
9. aware
10. today's
11. gentle
12. stunts
13. abuse
14. population
15. remembered
16. damage
17. threw
18. pity
19. except
20. reduce

SECOND WEEK

1. device
2. seek
3. there's
4. sleeves
5. blankets
6. rare
7. suppose
8. hurried
9. decide
10. crawl
11. treatment
12. degree
13. broad
14. causes
15. sole
16. proof
17. nickel
18. depth
19. insects
20. compare

THIRD WEEK

1. mistaken
2. consist
3. fetch
4. lease
5. moss
6. artist
7. clerks
8. folk
9. amusing
10. adjust
11. impress
12. mighty
13. conduct
15. hither
16. cottage
17. bridge
18. double
19. burnt
20. campus

FOURTH WEEK

1. mayor
2. worship
3. average
4. headquarter
5. watermelon
6. checkers
7. canal
8. cliff
9. empire
10. catalog
11. peanut
12. noticed
13. abroad
14. tunnel
15. men's
16. fare
17. quarter
18. expected
19. palace
20. oversight

FIFTH WEEK

1. furnish
2. chamber
3. regards
4. wages
5. admire
6. eager
7. beyond
8. chased
9. passage
10. written
11. pertaining
12. barrel
13. distant
14. complain
15. weigh
16. contact
17. steer
18. zebra
19. insult
20. comment

SIXTH WEEK

1. grandma's
2. soul
3. fitted
4. shone
5. convention
6. slight
7. salad
8. boiler
9. investment
10. how's
11. burst
12. habits
13. rotten
14. chalk
15. addressed
16. knit
17. captain
18. pumpkin
19. verses
20. management

SEVENTH WEEK

1. potato
2. brake
3. beautiful
4. wherever
5. dropped
6. requested
7. allow
8. Bible
9. really
10. agents
11. afterward
12. organ
13. comply
14. lying
15. restless
16. eighth
17. gotten
18. bleeding
19. angel
20. one-half

EIGHTH WEEK

1. figure
2. action
3. signal
4. presents
5. breaking
6. problem
7. colored
8. captured
9. largely
10. shade
11. forwarded
12. factor
13. scrap
14. liberty
15. bathe
16. sane
17. locate
18. journey
19. freshman
20. sentence

NINTH WEEK

1. chores
2. useless
3. strain
4. including
5. growth
6. entertain
7. tracer
8. officers
9. confess
10. arrived
11. disaster
12. here's
13. wisdom
14. union
15. collar
16. needle
17. pleasure
18. telephone
19. crush
20. bookkeeping

APPENDIX C

HANDWRITING

FOUR WEEK PROGRAM

September 13 - 17

Motivation and Scale Evaluation Characteristics of Letters

September 20 - 24

Form and Speed

September 27 - October 1

Slant and Spacing

October 4 - 8

Size - Line Quality - Re-evaluation

The following paragraph was used for evaluation:

I live in America. It is good to live where you have freedom to work and play. As an American, I support my country and what it stands for.

APPENDIX D

ACCURACY

September 7, 1965

The Monroe Adding Machine Company representative gave a twenty minute demonstration to both the experimental and control groups. The demonstration was a lesson in the proper use of a ten key hand operated adding machine.

September 9, 1965

Add

						48	47
84	22	79	23	53	69	67	56
78	53	32	75	81	91	16	65
92	36	63	69	32	75	83	73
43	59	46	27	26	18	58	69

				37	53	76	61
76	94	59	45	29	61	80	87
96	59	60	38	42	79	39	40
74	18	38	68	48	89	70	61
59	97	41	50	63	32	42	28
85	34	49	37	29	16	24	53

Subtract

81	113	417	871	723	700	4000
-37	87	283	236	109	254	1275

63	146	626	600	814	562	2206
29	29	491	417	297	129	997

Watch the signs:

17 + 4 =   32 + 9 =   87 - 5 =   65 - 6 =

24 + 7 =   59 - 3 =   76 + 6 =   44 + 9 =

39 - 5 =   38 + 8 =   85 - 23 =   96 - 33 =

September 14, 1965

1-	62	327	658	578	947	283
	79	409	356	853	256	1984
	18	126	622	895	908	643
	25	543	174	427	295	819
	46	188	429	247	509	2075

2-	27	265	501	337	195	7689
	19	547	734	384	393	324
	83	596	499	433	235	419
	60	285	161	675	869	2074
	56	639	702	654	318	1155

3- 87 - 5 = 36 - 8 = 45 - 3 = 68 - 4 =

4- 60 - 6 = 90 - 5 = 30 - 7 = 70 - 9 =

5- 52 - 9 = 71 - 4 = 35 - 8 = 64 - 6 =

6-	91	679	145	532	800	1788	2400
	-73	337	-92	-357	-463	-927	-1252

7-	58	471	126	600	332	5304	1222
	-46	-148	-79	-321	-257	-2388	-524

September 16, 1965

Subtract:

1-	4833 1246	2919 2437	6534 2635	73146 57457	70000 42398
2-	1655 687	5000 2465	4288 1535	16276 8628	35643 17967
3-	5018 4568	7188 3759	4000 2152	91421 72394	14932 6165

Add

1-	334 286 412 293	532 378 466 576	376 817 343 464	275 552 299 507	468 154 968 354
2-	173 216 835 637	343 850 979 468	897 928 654 149	301 417 241 603	128 694 149 744
3-	713 258 524 465	132 275 807 355	534 176 665 436	436 146 894 283	174 527 993 306

September 21, 1965

Find the missing answers

34	S	28	64	S	95	A
+S	+46	+94	+S	+72	-56	-35
57	99		142	140		46

76	A	62	S	41	55	73
-S	-15	-S	+39	-S	+S	+57
37	58	19	103	27	144	

A	611	S	295	S	587
-97	S	+354	+S	+576	+S
125	926	883	769	695	979

915	A	582	973	A
-S	-284	-379	-S	-185
692	543		827	509

S	881	517	S	134
+415	+367	-S	+234	+S
807		155	917	461

September 23, 1965

Subtract

1-	81	113	417	871	723	700	4000
	-37	87	283	236	189	234	1275

2-	63	146	626	600	814	562	2206
	29	29	491	417	297	129	997

Add

3-	3536	4715	1485	4382	3065
	4658	7863	8276	6644	656
	1943	935	6533	3600	274
	2206	1487	773	3579	3705

Subtract

4-	5402	5325	60001	90258	4367
	3865	4695	28423	63699	2369

5-	7674	43817	60000	259	956
	4837	16325	39753	239	481

Add

6-	146	845	156	968	376
	672	989	692	171	509
	759	417	526	420	482
	283	983	384	407	571
	314	755	627	819	248

September 28, 1965

Add

1-	628	683	296	793	957
	499	807	965	455	636
	714	965	887	677	738
	362	545	128	907	449

924	238	312	828	551
534	725	493	141	467
796	754	341	122	301
818	459	457	273	388

Subtract

2-	5689	8793	8761	4080	5549
	3462	2649	1896	3245	4196

3306	3476	7204	6458	4000
1737	1219	5244	5569	2496

Find the missing numbers

	18				
+12	+	+17	-15	-19	-14
26	24	35	23	36	31

22	33	28	
+	+	+	-28
39	65	54	67

September 30, 1965

Subtract

1-	35488 15254	58194 25475	43317 24654	80000 3086	32443 22578
2-	62385 47426	30000 14175	68230 23631	91554 23476	70002 49257

Add

3-	334 286 412 293	532 378 466 576	376 817 343 464	275 552 299 507	468 154 968 354
4-	173 216 835 637	343 850 979 468	897 928 654 149	301 417 241 603	128 694 149 744

Subtract

5-	86565 67078	50923 33653	73873 38986	66925 19389	8060 7935

Add

6-	713 258 524 465	132 275 807 355	534 176 665 436	486 146 894 283	176 527 993 306

October 5, 1965

Subtract

5698	9795	7003	5864	6542
3646	9539	3835	4368	965

3817	9325	5368	6000	3238
3466	4657	928	5265	2899

Add

509	193	189	350	3689
86	741	857	29	545
221	436	44	43	1331
74	86	52	259	177
122	79	408	490	1485
637	298	135	427	3642

Subtract

9182	4850	7784	5562	5000
5898	2866	797	3583	2517

5546	9221	7692	6785	3000
1448	234	7424	3135	1353

8003	8926	$52.12	$60.56	$29.61
2987	8171	37.23	4.46	19.79

October 7, 1965

196	232	466	611	734	615
+147	+561	+123	+436	+861	+720
-205	-344	-377	-410	-943	-306

Subtract

2869.45	6000.00	1200.50	6151.55	8000.00
984.68	1572.43	489.56	4121.69	7639.74

67148	29784	25394	14570	62700
25025	16995	16875	13868	28469

12547	70034	80000	65136	33959
10868	56229	40259	53854	17066

Add

2217	3007	1589	2669	3249
482	8757	1622	874	456
3453	3686	968	4357	4477
2248	2850	747	2396	1576
574	3469	1944	253	1032

1032	3240	2516	3702	9970
281	5385	967	3589	434
9691	764	3945	1299	6447
569	2395	657	1865	668
7453	345	1438	2599	8089

October 12, 1965

1-	146 +232 -104	433 +610 -573	732 +249 -467	611 +499 -782	710 +135 -463	613 +478 - 10

2- 19.6-14.7= 1.82-44= 454-274=

3- 500.00-375.39= 52.8-44.2= 5.13-2.50=

4- 79.0-25.5= 6.54-.58= 640.00-494.26=

5-	16.18 49.00 56.86 46.05 47.37	36.75 79.77 74.43 5.63 21.34	14.52 9.89 33.55 25.38 16.66	66.38 7.54 14.47 76.54 54.44	32.47 51.26 67.94 81.04 36.39
6-	4216 -2384	5572 -4853	4353 -1499	8428 -4369	7413 -2436
7-	3122 -1999	5000 -2327	8528 -2662	8387 -1597	6271 -5795
8-	149 +633 -123	673 +542 -411	833 +651 -504	927 +433 -344	100 +500 -146

October 14, 1965

1-	432 +698 -123	545 +499 -162	984 +236 -650	412 +378 -111	378 +665 -407
2-	2407 -135	3586 -803	1946 -217	5687 -693	9613 -450
3-	7593 -5259	2018 -1893	6874 -1974	3502 -467	5280 -1205
4-	1652 789 2203 937 756	6478 749 4375 343 310	1549 429 6984 262 677	3675 7977 7443 563 2134	14527 98902 33355 25382 16266
5-	2217 482 3453 2248 574	3007 8757 3686 2850 3469	1589 1622 968 747 1944	26693 87464 43571 23936 23545	32492 45629 44727 15760 10323
6-	659 +322 -233	454 +949 -261	849 +326 -506	214 +783 -997	873 +565 -707

October 19, 1965

436 +614 -406	598 +266 -189	711 +636 -366	833 +467 -674	1054 +1161 -1347
433 688 768 943 176	544 787 138 494 886	989 134 464 555 198	673 445 898 343 712	646 133 748 626 1044
349 +688 -404	986 +737 -198	683 +405 -176	1055 +9033 -6853	1193 +8648 -6854
565 492 874 435 712	939 474 532 163 764	714 826 +147 -613	613 432 +713 -414	933 821. +505 -389
13924 -8697	22183 -15613	46054 28669	51122 -7935	
58334 51385	35947 8494	14200 5234	59182 35874	

October 21, 1965

431 420 813 196	724 904 861 354	827 684 758 866	4513 9754 267 755	9218 2370 567 9068
618 +896 -565	357 +883 -343	9419 +7656 -6073	4150 +5241 -6112	1352 +6135 - 404
1148 9386 9989 4579 9068	5085 8375 7668 9737 755	3856 7867 8784 4979 101	3621 6787 4278 6379 1010	242 732 6 36 21
550 -431	2734 -742	8357 -3365	98765 -86444	12381 -3582
976 +372 -133	12455 +8888 -7676	985 +632 -100	32033 +9999 -8686	6318 +3475 -1123
6534 -4667	7998 -2722	8967 -6822	75442 -65578	8895 -4845

October 26, 1965

436 +676 -143	9062 +1783 -4242	7677 +1364 -1232	6832 +4232 - 838	7063 +6984 - 615
1323 6744 8723 6832	9324 1363 4164 7464	8613 4244 7361 8208	9499 8613 4268 1003	7172 6343 145 6876
7364 -1342	8601 -7698	4345 -1598	4368 -2232	6849 -5909
444 +686 -135	561 434 +681 -323	732 +868 -568	7098 -1659	8989 -6666
793 468 735 904	8436 9365 8060 4323	6986 4368 5032 7377	4341 9062 7362 4089	7777 6812 3276 4489
4689 -1368	56898 -23689	46861 -17893	7383 -6869	71012 -66130

October 28, 1965

1-	7064	6045	9056	8093	6045
	-3285	-1587	-7689	-3897	-2796
2-	6010	8010	7004	9006	6007
	-3784	-5491	-2929	-5307	-4419
3-	4375	1264	2989	$81.75	3523
	6098	4796	5685	.59	2501
	7254	2798	2507	6.43	2684
	2109	3887	6706	79.87	4999
	8175	7987	2853	21.09	5080
4-	974		58	499	
	+	+296	+	+	-1423
	1002	303	855	1007	4817
5-	1264	2798	2989	2507	2853
	+4796	+3887	+5685	+6706	+ 88
	-1030	-4213	-6847	-2931	-1492
6-	13864	84350	76132	11124	10321
	+62932	+14683	+13683	+88686	+93201
	-50673	-63604	-89815	-99810	-62163

November 2, 1965

Watch the signs

413 + 836	511 + 1404	673 + 935	781 - 404	966 - 610

2653 -895	942 -573	7437 -6255	4638 -2846	92761 -65970

3742 8631 1475	4045 8628 3791	2496 384 4275	6802 2213 3729	4975 6105 4398
- 847	-5070	- 36	-4987	-9865

57390 -34857	20793 -17621	29653 -1217	18349 -2673	34765 -12786

32596 +8371	46728 +1596	21479 +8521	64047 -38659	68400 -62534

71524 37229 36272 60020	2730 6002 2791 9703	9283 6513 9286 9064	6793 6535 4786 8365	1625 5923 4876 3774

November 4, 1965

1463 +6302 -4303	1684 +4971 -1309	7613 +4414 -6898	4748 +1070 -681	325 +146 -109
9083 -6135	7365 -4973	3892 -2475	5183 -3486	49580 -7321
7321 583 4932	6748 7659 85	325 9685 3765	5963 839 7532	23750 4825 673
468 -279 +684	8500 -685 +135	7895 -854 +968	2005 -347 +1968	8967 -3425 +5542
4132 321 213 121	875 476 329 8720	1234 3412 2615 3172	8977 4675 1352 683	4563 2518 224 468
2653 -895	942 -573	7623 +492	4638 -2846 +1792	9276 -6597 +1638

APPENDIX E

MATHEMATICS

September 8, 1965

Addition Facts

You learned 100 addition facts. You should know the easy addition facts. Let us see if you know 36 of the more difficult addition facts.

Write the answers for these addition sentences.

8 + 4 = ___
4 + 8 = ___

8 + 3 = ___
3 + 8 = ___

8 + 7 = ___
7 + 8 = ___

9 + 5 = ___
5 + 9 = ___

6 + 6 = ___

7 + 3 = ___
3 + 7 = ___

9 + 3 = ___
3 + 9 = ___

7 + 6 = ___
6 + 7 = ___

9 + 6 = ___
6 + 9 = ___

7 + 7 = ___

6 + 5 = ___
5 + 6 = ___

7 + 4 = ___
4 + 7 = ___

8 + 5 = ___
5 + 8 = ___

9 + 7 = ___
7 + 9 = ___

8 + 8 = ___

7 + 5 = ___
5 + 7 = ___

8 + 6 = ___
6 + 8 = ___

9 + 4 = ___
4 + 9 = ___

9 + 8 = ___
8 + 9 = ___

9 + 9 = ___

 67 addend
+22 addend
 89 sum

In the example, the numbers ________ and ________ are addends.

When two or more numbers are added, the answer is called the ______.

Circle the sign for addition: + - x ÷

Write the addends on the first line and the sum on the second line.

1. Henry sold 42 newspapers on Monday and 45 on Tuesday. How many newspapers did he sell in two days? ________ ________

2. Dale mowed lawns for neighbors. He earned $32 during June and $43 during July. How much did he earn during June and July? ________ ________

September 8, 1965

Subtraction Facts

You learned 100 subtraction facts. You should know the easy subtraction facts. Let us see if you know 36 of the more difficult facts.

Write the answers for these subtraction sequences.

11 - 2 = ___ 11 - 3 = ___ 11 - 4 = ___ 11 - 5 = ___
11 - 9 = ___ 11 - 8 = ___ 11 - 7 = ___ 11 - 6 = ___

12 - 3 = ___ 12 - 4 = ___ 12 - 5 = ___ 13 - 4 = ___
12 - 9 = ___ 12 - 8 = ___ 12 - 7 = ___ 13 - 9 = ___

13 - 5 = ___ 13 - 6 = ___ 14 - 5 = ___ 14 - 6 = ___
13 - 8 = ___ 13 - 7 = ___ 14 - 9 = ___ 14 - 8 = ___

15 - 6 = ___ 15 - 7 = ___ 16 - 7 = ___ 17 - 8 = ___
15 - 9 = ___ 15 - 8 = ___ 16 - 9 = ___ 17 - 9 = ___

12 - 6 = ___ 14 - 7 = ___ 16 - 8 = ___ 18 - 9 = ___

847 minuend
-213 subtrahend
634 remainder

In the example, the number ______ is the minuend; the number ______ is the subtrahend.

When one number is taken from another number, we call the answer the __________.

Circle the sign for subtraction: + - x ÷

Write the minuend on the first line, the subtrahend on the second line, and the remainder on the third line.

1. Charles earned 75 cents during the first week of his summer vacation and 50 cents the second week. How much more did he earn the first week than the second?

________ ________ ________

2. Frank visited the navy yard. Yesterday he saw 36 ships and today he saw 57 ships. How many more ships did Frank see today than yesterday?

________ ________ ________

September 10, 1965

Addition of Tens and Ones

54 = 5 tens 4 ones
43 = 4 tens 3 ones
7 9 tens 7 ones
or
90
97 = 90 + 7 = 97

Add the ones.
4 + 3 = 7.
Add the tens.
5 + 4 = 9.

Write the addition sentence for the example.

Put in the missing numbers. Write the sums.

63 = tens ones
36 = tens ones

74 = tens ones
30 = tens ones

Add.

48	86	73	82	64	53
31	53	45	24	14	32

63	95	60	55	73	84
74	80	47	44	65	70

Add ones to tens and ones.

74 = 7 tens 4 ones
5 = 0 tens 5 ones
79 = 7 tens 9 ones
or
70 + 9 = 79

Add the ones.
4 + 5 = 9.
Add the tens.
7 + 0 = 7.

15	33	28	76	54	83
4	5	1	2	3	6

65	2	11	3	91	5
3	73	8	24	4	42

September 10, 1965

Column Addition

Add from the top down.
To check, add from the bottom up.

5				
2	7	Think: 7, 14,22,23.	42	Column one.
7	14		31	Think: 2,3,5,8.
8	22		52	Column two.
1	23		63	Think: 4,7,12,18.
23		The sum is 23.	188	The sum is 188.

Add and check.

3	1	6	9	7	8
8	7	0	1	4	9
5	2	5	3	0	4
4	9	8	2	6	0

3	5	9	4	9	6
6	8	1	2	1	5
2	0	6	5	4	2
1	7	7	8	0	9
4	3	0	3	7	8

21	45	57	72	55	43
32	81	90	83	80	62
50	63	31	60	71	21
76	20	41	94	93	90

Add across from left to right. Check from right to left.

4 + 1 + 3 + 2 = ______
4 + 5 + 3 + 6 = ______
7 + 8 + 2 + 3 = ______
5 + 2 + 0 + 6 = ______
2 + 8 + 9 + 6 = ______

6 + 1 + 3 + 4 = ______
7 + 0 + 8 + 1 = ______
7 + 8 + 1 + 9 = ______
9 + 0 + 7 + 5 = ______
8 + 4 + 7 + 6 = ______

September 13, 1965

Addition with Carrying

1. Mr. Brown planted some trees in his orchard. He planted 55 peach trees, 76 apple trees, and 24 pear trees. How many trees did he plant?

____

2. Mr. Brown counted the apple trees in the first three rows of his orchard. He counted 38 trees in the first row, 27 trees in the second row, and 46 trees in the third row. How many trees did he count?

____

3. Mr. Brown then counted the peach trees. He counted 64 trees in the first row, 75 trees in the second row, and 59 trees in the third row. How many peach trees did Mr. Brown count?

____

Add and check.

68	77	86	27	39	18
89	76	39	69	45	36
56	69	76	15	28	27

53	25	20	88	87	97
74	82	17	34	64	35
66	49	68	50	73	70

6	80	65	90	88	7
81	6	75	48	60	57
35	44	2	5	4	70

September 13, 1965

A Bookstore

Mrs. Taylor sold 92 books from a shelf containing 148 book. How many books remained on the shelf?

____

$$\begin{array}{rl} 148 & \text{books} \\ -92 & \text{books} \\ \hline 56 & \text{books} \end{array}$$

Subtract the ones.
Subtract the tens.
5 tens and 6 ones = ______________

1. Mrs. Taylor sold 48 pencils from a box containing 128 pencils. How many pencils remained to be sold?

____

2. Mrs. Taylor had 115 packs of paper and sold 54 packs. How many packs of paper were left?

____

3. Mrs. Taylor bought 135 new books on the first day of the month. During the month she sold 95 of them. How many books did she have left?

____

4. Mrs. Taylor had 124 birthday cards in her store. Mary and her classmates bought 31 of them. How many birthday cards were left?

____

5. The third grade class decided to buy adventure books for the library. They found 129 adventure books at the bookstore and bought 36 of them. How many adventure books remained in the store?

____

September 15, 1965

Adding Three-Place Numbers

	hundreds	tens	ones
752 =	7	5	2
436 =	4	3	6
1188 =	11	8	8

1100 + 80 + 8 = 1188

Add the ones.
2 + 6 = 8.
Add the tens.
5 + 3 = 8.
Add the hundreds.
7 + 4 = 11.

Write the addition sentence for the example.

____

Put in the missing numbers. Write the sums.

	hundreds	tens	ones
645			
634			

	hundreds	tens	ones
317			
821			

Write the sums for these examples.

45	61	30	45	61	84
61	84	95	80	47	21
10	23	44	33	60	73

421	624	704	345	210
134	350	154	421	367
541	113	131	213	312

451	652	840	741	524
406	314	126	541	351
341	723	233	215	502

September 15, 1965

Problems

1. In Mr. Arnold's store there were 63 bicycles. Because of the Christmas holidays, he bought 36 more. How many bicycles did he have then?

__________ number of bicycles he had.

__________ number of bicycles he bought.

__________ number of bicycles he had then.

2. There are 284 boys and 315 girls in the Franklin School. How many pupils are there in the Franklin School?

__________ boys in the Franklin School.

__________ girls in the Franklin School.

__________ pupils in the Franklin School.

3. John spent 20 cents for a coloring book, 12 cents for crayons, and 25 cents for a pen. How much did John spend?

__________ cost of the book.

__________ cost of the crayons.

__________ cost of the pen.

__________ total cost.

4. Lt. Hess flew 424 miles with his Army airplane. Capt. Day flew 450 miles; and Lt. Col. Glenn flew 323 miles. How many miles did the three officers fly?

__________ miles Lt. Hess flew.

__________ miles Capt. Day flew.

__________ miles Lt. Col. Glenn flew.

__________ miles the three officers flew.

September 17, 1965

United States Money

$3.37 .21 6.41 $9.99	Dollars 16	 .	Cents 25	$3.46 -1.23 $2.23
	$16.25			

Be sure to put the dollar sign and cents point in each answer.

Add.

$3.45 4.34	$5.61 5.36	$7.26 .72	$6.20 6.45	$8.50 .40
$2.31 1.25 4.32	$4.26 2.42 5.11	$6.34 3.15 5.50	$7.30 4.23 4.03	$9.20 8.00 2.45
$7.64 .12 4.20	$5.00 6.74 .20	$6.03 .83 8.10	$9.24 .51 7.00	$6.21 3.10 .45

Subtract.

$9.84 8.23	$1.75 .92	$6.79 4.53	$8.64 .33	$9.00 4.00
$10.00 6.00	$12.35 8.21	$15.84 7.32	$14.75 9.60	$11.54 5.24
$18.07 9.07	$12.84 7.00	$16.27 9.27	$10.98 3.90	$18.87 9.35

September 17, 1965

Money Problems

Be sure to put the dollar sign and the cents point in the answer. Show your work.

1. Henry bought a baseball outfit for $9.25 and a football for $5.10. How much money did he spend?

____

2. George has $9.75. He wants to buy a baseball and a bat that will cost $3.75. If he buys the baseball and bat, how much money will he have left?

____

3. Alice bought a dress for $4.25, a pair of shoes for $6.00, and a sweater for $5.20. Alice spent ______________.

4. Jack worked three days. The first day he earned $4.50, the second day $5.00, and the third day $6.25. How much did Jack earn in three days?

____

5. The pupils in Helen's class have a saving's plan. The first week they saved $3.54, the second week $4.10, and the third week $5.35. The girls saved ________________ in three weeks.

6. Mr. Davis earned $59.75 in one week. He paid $22.50 for food. Mr. Davis had ________________ left.

September 22, 1965

Missing Numerals

Put the missing numerals in each example.

$\begin{array}{r} 34 \\ + \\ \hline 57 \end{array}$	$\begin{array}{r} \\ +46 \\ \hline 99 \end{array}$	$\begin{array}{r} 28 \\ +94 \\ \hline \end{array}$	$\begin{array}{r} 64 \\ + \\ \hline 142 \end{array}$	$\begin{array}{r} \\ +72 \\ \hline 140 \end{array}$
$\begin{array}{r} 95 \\ -56 \\ \hline \end{array}$	$\begin{array}{r} \\ -35 \\ \hline 46 \end{array}$	$\begin{array}{r} 76 \\ - \\ \hline 37 \end{array}$	$\begin{array}{r} \\ -15 \\ \hline 58 \end{array}$	$\begin{array}{r} 62 \\ - \\ \hline 19 \end{array}$
$\begin{array}{r} \\ +39 \\ \hline \end{array}$	$\begin{array}{r} 41 \\ - \\ \hline \end{array}$	$\begin{array}{r} 55 \\ + \\ \hline \end{array}$	$\begin{array}{r} 73 \\ +57 \\ \hline \end{array}$	$\begin{array}{r} \\ -97 \\ \hline \end{array}$
$\begin{array}{r} 611 \\ + \\ \hline 926 \end{array}$	$\begin{array}{r} \\ +354 \\ \hline 883 \end{array}$	$\begin{array}{r} 295 \\ + \\ \hline 769 \end{array}$	$\begin{array}{r} \\ +576 \\ \hline 695 \end{array}$	$\begin{array}{r} 587 \\ + \\ \hline 979 \end{array}$
$\begin{array}{r} 915 \\ - \\ \hline 692 \end{array}$	$\begin{array}{r} \\ -284 \\ \hline 543 \end{array}$	$\begin{array}{r} 582 \\ -379 \\ \hline \end{array}$	$\begin{array}{r} 973 \\ - \\ \hline 827 \end{array}$	$\begin{array}{r} \\ -185 \\ \hline 509 \end{array}$
$\begin{array}{r} \\ +415 \\ \hline 807 \end{array}$	$\begin{array}{r} 881 \\ -367 \\ \hline \end{array}$	$\begin{array}{r} 517 \\ - \\ \hline 155 \end{array}$	$\begin{array}{r} \\ +234 \\ \hline 917 \end{array}$	$\begin{array}{r} 134 \\ + \\ \hline 461 \end{array}$

September 24, 1965

Dollars and Cents

The dollar sign ($) and the cents point (.) are used in writing dollars and cents. The name for the "cents point" is "decimal point." It is used to show parts of a dollar.

Add.

$16.45 9.70 $26.15	Add the cents first, the dimes next, and then the dollars. Always keep the decimal points directly under each other in adding money.

$5.65 1.25	$2.67 8.52	$2.44 7.58	$8.53 5.49	$9.46 6.72
$17.80 6.09	$26.15 8.90	$18.05 7.48	$44.65 8.77	$16.30 5.80
$12.75 26.29	$34.45 15.82	$16.80 47.33	$18.03 4.07	$17.00 14.00

Subtract.

$14.25 6.12 $ 8.13	Subtract the cents first, the dimes next, and then the dollars. Write the dollar sign and the cents point in each answer.

$5.25 2.10	$6.40 3.20	$4.68 2.54	$9.50 4.00	$8.66 6.46
$12.75 4.25	$11.60 6.40	$13.78 7.50	$12.70 5.70	$17.80 9.30
$1.25 .25	$1.50 .70	$1.45 .82	$1.00 .60	$1.70 .90

September 24, 1965

Buying and Selling

1. Pete went on a two-day trip with his father. The first day he spent $5.35 and the second day $3.70. How much did Pete spend on the trip?

____

2. Lois spent $9.25 for a pair of shoes and $3.75 for a hat. The shoes and hat cost

____________________.

3. Russell earned $14.80 the first week in July and $7.50 the second week. He earned ____________________ more the first week than the second.

4. Connie had $10.75. She spent $9.50 for a puppy. How much money did she have left?

____

5. Mr. Pharo received $8.25 from the sale of black raspberries and $6.75 from the sale of red raspberries. He received __________ from the sale of the berries.

6. Lewis wants to save $27.50 for Christmas. He has already saved $9.25. How much more must he save?

____

7. Charles wants to buy a pair of ice skates that cost $8.25. He has saved $4.65. How much more does Charles need to save to pay for the skates?

____

September 27, 1965

The Missing Number

In the examples on this page, the N stands for a missing number.

$N + 3 = 10$	In this number sentence N stands for the missing number.
$N = 10 - 3$ $N = 7$	To find N, we subtract. $10 - 3 = 7$. The missing number is 7.
$N - 5 = 4$ $N = 5 + 4$ $N = 9$	To find N in this example, we add. $5 + 4 = 9$. The missing number is 9.

$N + 4 = 7$
N =

$N - 3 = 6$
N =

$5 + N = 8$
N =

$N - 4 = 9$
N =

$N + 6 = 14$
N =

$12 + N = 16$
N =

$N + 5 = 28$
N =

$N - 9 = 35$
N =

$N + 5 = 9$
N =

$N - 2 = 7$
N =

$6 + N = 10$
N =

$N - 5 = 7$
N =

$N - 9 = 8$
N =

$22 - N = 17$
N =

$N - 3 = 22$
N =

$N - 7 = 43$
N =

$N + 3 = 5$
N =

$N - 6 = 3$
N =

$7 + N = 12$
N =

$N - 8 = 7$
N =

$8 + n = 15$
N =

$N - 9 = 11$
N =

$27 + N = 34$
N =

$38 + N = 50$
N =

September 27, 1965

Problems

Use N in writing the number sentences to solve these problems.

Work Space

1. There were 34 pupils in a class. Sixteen of them were boys. How many girls were in the class?

N + 16 = 34
N =

____

2. George had 65¢. His father gave him 30¢. George now has __________ cents.

65 + 30 = N
N =

3. Ray had 36 marbles in his bag. How many marbles did Ray have after he bought 43 more marbles?

____

4. The fifth grade bought 14 new books for the room library. There are now 72 books in the library. The library had ________ books before the new books were bought.

5. There are 68 desks in the art room and the music room. In the art room there are 32 desks. There are _______ desks in the music room.

6. The fifth-grade pupils visited the museum. Out of a class of 34 pupils, 8 did not go to the museum. How many pupils went to the museum?

____

7. Sam sold 35 magazines one day. The next day he sold 23 magazines. Sam sold _____ magazines in all.

September 29, 1965

Regrouping Twice in Subtraction

						Regrouped			
		hundreds	tens	ones		hundreds	tens	ones	
764	=	7	6	4	=	6	15	14	
578	=	5	7	8	=	5	7	8	
186						1	8	6	or
						100 +	80 +	6 = 186	

By regrouping 764 into 6 hundreds, 15 tens, and 14 ones, you can subtract 8 ones from 14 ones and 7 tens from 15 tens.

Write an example. Solve it. Regroup if necessary.

						Regroup		
		hundreds	tens	ones		hundreds	tens	ones
	=							
	=							

Solve these examples.

563 178	816 347	620 258	327 267
1224 418	1736 908	1563 786	1500 327
2824 1536	9563 5486	7985 3995	8004 5612
$9.50 5.73	$18.23 9.42	$82.36 68.48	$75.00 60.76

September 29, 1965

Number Sentences

In the examples on this page, the N stands for the missing number.

N + 24 = 49
N = 49 - 24
N = 25

To find N, we subtract.
49 - 24 = 25.
The missing number is 25.

N - 31 = 42
N = 42 + 31
N = 73

To find N in this example, we add.
42 + 31 = 73.
The missing number is 73.

N + 12 = 26
N - 15 = 23
22 + N = 39
N - 28 = 67
N + 56 = 71

N + 18 = 24
N - 19 = 36
33 + N = 65
N - 34 = 72

N + 17 = 35
N - 14 = 31
28 + N = 54
N - 45 = 87

October 1, 1965

Missing Numerals

Put the missing numerals in each example.

34 + ___	+46 ___	28 +94 ___	64 + ___	+72 ___
95 -56 ___	-35 ___	76 - ___	-15 ___	62 - ___
+39 103				

Nickel 5¢	Dime 10¢	Quarter 25¢	Half Dollar 50¢

1 nickel = ___ cents
1 dime = ___ nickels
1 dollar = ___ cents
1 dollar = ___ quarters
1/2 dollar = ___ quarters
50 cents = ___ quarters
70 cents = ___ dimes
300 cents = ___ dollars
4 quarters = ___ dollar
40 cents = ___ nickels

1 dime = ___ cents
1 quarter = ___ cents
1 quarter = ___ nickels
1 dollar = ___ dimes
1/2 dollar = ___ cents
50 cents = ___ dimes
10 cents = ___ dime
100 cents = ___ dollar
8 dimes = ___ cents
8 quarters = ___ dollars

$ 2.48 = ___ dollars ___ quarter ___ dimes ___ cents
$ 4.98 = ___ dollars ___ quarters ___ dimes ___ cents
$10.48 = ___ dollars ___ quarter ___ dimes ___ cents
$18.74 = ___ dollars ___ half dollar ___ dimes ___ cents
$14.65 = ___ dollars ___ half dollar ___ dime ___ nickel

October 4, 1965

Multiplication with Carrying

24 X3 72	24 24 24 72	Multiply the ones. 3 X 4 = 12. Write the 2 in ones' place. Carry the 1 ten to tens' place. Multiply the tens. 3 X 2 = 6. The 6 tens plus the 1 ten carried equal 7 tens. Write 7 in tens' place. The product is 72.

The multiplication sentence for this example is 3 X 24 = 72.

The tens and ones can also be multiplied in two separate steps.

3 X 24 = (3X4) + (3X20) = 12 + 60 = 72.

Multiply. Check your work carefully.

26 5	47 2	28 3	35 4	19 3	18 2
79 2	57 5	36 3	19 4	56 2	14 3
45 2	44 3	48 5	37 3	39 4	46 2
67 4	68 3	59 4	56 5	27 2	29 5

Put the missing numerals in each of these sentences.

4 X 38 = (4 X __) + (4 X __) = ___ + ___ = ___

3 X 45 = (3 X __) + (3 X __) = ___ + ___ = ___

2 X 96 = (2 X __) + (2 X __) = ___ + ___ = ___

5 X 67 = (5 X __) + (5 X __) = ___ + ___ = ___

October 4, 1965

Problems

Write the multiplication sentences for these problems in the work space.

1. There are 14 boys on each of 4 teams in a small baseball league. How many boys belong to the league?

____

2. In order to fit the boys properly with uniforms, each team owns 17 uniforms. The 4 teams own ________________ uniforms.

3. At 49¢ each, what would 3 books cost Ann?

____

4. Allen has a stamp book. If 36 stamps fill a page and he has 5 pages filled, how many stamps are in his book?

____

5. There are 2 pints in 1 quart. How many pints are in 75 quarts?

____

6. Charles bought 3 small airplanes. They cost 28¢ each Charles paid ________________ cents for the airplane.

7. Wilson practices on his trumpet 45 minutes each day. How many minutes would he practice in 3 days?

____

October 6, 1965

Subtracting with zeros

1-	300	500	700	900	400	506	307	480
	137	396	362	425	284	139	108	240
	300	500	800	700	$15.50	$26.00	$38.04	$18.00
	76	45	92	84	2.50	13.57	16.27	17.75

Subtract - Check the remainders

2-	800	600	600
	-135	246	236

Add

3-	511	643	431	623
	215	512	728	750
	193	388	648	738
	765	$4.25	$7.40	$8.06
	852	3.12	3.98	1.90
	504	2.98	2.79	2.28

Multiply

4-	36	25	35	64	53	61	40	27
	x4	x2	x3	x3	x5	x5	x3	x2

Divide

5- $2\overline{)24}$ $3\overline{)36}$ $3\overline{)96}$

October 8, 1965

Add

1-	511	643	431	623	546	374	450	376
	215	512	728	750	176	206	325	425
	193	388	468	738	245	262	604	134
	623	611	113	612	122	107	292	651

$4.25	$7.40	$8.06	$5.14	300	765	$7.52	$4.11
3.12	3.98	1.90	8.52	445	852	8.33	6.27
2.98	2.79	2.28	6.36	609	504	6.34	4.35
				280	145	4.25	9.62

Subtract

2-	962	841	757	472	375	993	865	736
	-643	-514	-238	-249	-149	-728	-426	-317

1157	1064	1238	1489
-743	-532	-727	-865

Find the Missing Number

43	62		42
-	+	+53	-
12	108	114	33

Multiply

35	47	52	44
x6	x6	x5	x4

October 11, 1965

Borrowing Twice in Subtraction

									Regrouped	
		Dollars		Dimes	Cents		Dollars		Dimes	Cents
$6.72	=	6	.	7	2	=	5	.	16	12
-3.85	=	-3	.	8	5	=	3	.	8	5
$2.87							2	.	8	7
									or	
									$2.87	

By regrouping $6.72 into 5 dollars, 16 dimes, and 12 cents, you can subtract 5 cents from 12 cents and 8 dimes from 16 dimes.

Put the missing numbers in each group. Regroup if necessary. Write the answers.

									Regroup	
		Dollars		Dimes	Cents		Dollars		Dimes	Cents
$5.23	=									
-3.77	=									

$5.48	=									
-4.69	=									

Subtract.

$7.18 4.29	$7.42 6.77	$8.25 5.66	$9.37 6.58
$37.23 14.34	$73.42 71.88	$47.27 34.48	$87.12 74.63
$54.76 12.87	$79.23 35.27	$65.34 61.75	$98.55 95.66

October 11, 1965

Buying and Selling

1. Mr. Davis spent $20.50 for a tire, $4.75 for an inner tube, and $2.75 for gasoline. He gave the dealer $30.00. How much change should he have received?

____

2. Walter earned $33.75 in two months mowing lawns. He wants to buy a bicycle that costs $67.50. How much more money does he need?

____

3. Mrs. Ranck has $9.42. She bought meat for $1.35, sugar for $1.05, juice for $1.36, and flour for $2.48. Her bill was _______________. How much money did she have left?

____

4. The pupils in Kay's fourth-grade room have a savings plan. The first week they saved $4.65, the second week $5.28, and the third week $2.95. How much did they save in three weeks?

____

5. Dick weighs 67 pounds, Hugh weighs 74 pounds, and Don weighs 85 pounds. What is the total weight of the boys?

____

6. Grace had $25.00. She bought a new dress for $9.95, new shoes for $6.50, and a new hat for $3.98. Grace had ___________ left.

7. Mrs. Foose bought beef for $1.89, pork for 78 cents, and bacon for 52 cents. Mrs. Foose spent _______________ for meat.

October 13, 1965

Regroup

dollars dimes pennies

$5.32
-3.79

$7.11
-3.65

$8.06
-4.39

46 -17	77 -49	32 -23	84 -66	98 -79
56 -48	70 -53	63 -38	60 57	95 -67

278 -109	532 -366	401 -299	812 -631

132 + N = 562
N =

Add

476 383 521	243 765 189	113 426 589	301 285 467	200 794 569	215 451 624
231 845 126	365 406 534	470 554 137	617 700 125	820 742 139	800 900 300

Multiply

43 x6	57 x3	94 x4	101 x 5	67 x5	43 x5	88 x8	73 x7

October 15, 1965

Watch the Zeros

Write the number sentences for these problems in the work space.

1. Lester sold 306 tickets at the baseball game. If 137 of them were adult tickets, how many tickets were sold to pupils?

____

2. Earl and Carl together sold 1560 newspapers last week. Carl sold 724 of them. Earl sold ______________ newspapers.

3. Mr. Lontz planted 700 trees in two orchards. In one orchard he planted 450 trees. How many trees did he plant in the other orchard?

____

4. The Curtin School has 600 pupils and the Jackson School has 381 pupils. There are ______________ more pupils in the Curtin School than in the Jackson School.

5. Sarah attended school 180 days last year. Grace attended 167 days. Grace attended ______________ fewer days than Sarah.

6. Mr. Ross sold 905 gallons of gasoline. Mr. Jones sold 750 gallons. How many more gallons of gasoline did Mr. Ross sell than Mr. Jones?

____

October 15, 1965

Zeros in Subtraction

		hundreds	tens	ones		Regrouped hundreds	Regrouped tens	Regrouped ones
600	=	6	0	0	=	5	9	10
236	=	2	3	6	=	2	3	6
364						3	6	4

or

300 + 60 + 4 = 364

By regrouping 600 into 5 hundreds, 9 tens, and 10 ones, you can subtract 6 ones from the 10 ones and 3 tens from the 9 tens.

Put the missing numbers in each example. Write the remainders.

		hundreds	tens	ones	Regroup hundreds	Regroup tens	Regroup ones
800	=						
135	=						
600	=						
246	=						

Subtract. Check the remainders.

300	500	700	900	400	506	307	480
137	396	362	425	284	139	108	240

300	500	800	700	600
76	45	92	84	33

$15.50	$26.00	$38.04	$24.50	$18.00
2.50	13.57	16.27	3.75	17.75

October 18, 1965

Regrouping in Addition

965 = 9 hundreds 6 tens 5 ones
486 = 4 hundreds 8 tens 6 ones
1451 = 13 hundreds 14 tens 11 ones
or
14 hundreds 5 tens 1 one
or
1400 + 50 + 1 = 1451

You regroup the 11 ones into 1 ten and 1 one. Add the 1 ten to the 14 tens. 14 + 1 = 15.

You regroup the 15 tens into 1 hundred and 5 tens. Add the 1 hundred to the 13 hundreds.

Put the missing numbers in the example. Regroup the sum if necessary. Write the sum.

478 = hundreds tens ones
254 = hundreds tens ones

Add. Check your work.

511	643	431	623	765
215	512	728	750	852
193	388	648	738	504

546	374	450	376	300
176	206	325	425	445
245	262	604	134	609
122	107	292	651	280

$4.25	$7.40	$8.06	$5.14	$7.52
3.12	3.98	1.90	8.52	8.33
2.98	2.79	2.28	6.36	6.34

October 18, 1965

Indicating Processes

On the first line under each problem write an A if you add to solve the problem; or an S if you subtract. Write the answer on the second line.

1. Ted went to the grocery store for his mother. He bought a pound of butter for 72 cents and a dozen eggs for 48 cents. How much did he pay for both the butter and the eggs?

______ ______

2. Ruth wanted to buy a book that cost 95 cents. She had only 69 cents. How many more cents did she need?

______ ______

3. Caroline has read to page 119 in her history book. The book has 268 pages in it. How many more pages does she have to read?

______ ______

4. Hilda and Stella made sandwiches for a class picnic. They made 38 peanut butter sandwiches and 42 cheese sandwiches. How many sandwiches did they make?

______ ______

5. One Sunday morning John took 55 papers to sell. In two hours he had sold 46 of them. How many papers did he have left to sell?

______ ______

6. Helen and Vivian ate lunch at the school cafeteria. Helen's lunch cost 36 cents; and Vivian's lunch cost 39 cents. How much did they pay for both lunches?

______ ______

October 20, 1965

Subtract

300	800	400	500	402	700	300	200
107	448	394	129	359	292	65	172

900	901	405	700	306	800	907	651
816	608	239	81	7	98	489	289

946	305	955	967
79	268	256	469

Add

53	24¢	9	25¢	86
14	30¢	497	19¢	9
22	25¢	298	43¢	30
				27

433	544	989	673	646	349
688	787	134	445	133	121
768	138	464	898	748	900
943	494	555	343	626	134

349	986	683	1055	711
+688	+737	+405	+9033	+636
-404	-198	-176	-10088	-366

October 25, 1965

Borrowing Tens in Subtraction

							Regrouped	
		hundreds	tens	ones		hundreds	tens	ones
751	=	7	5	1	=	7	4	11
423	=	4	2	3	=	4	2	3
328						3	2	8

or

300 + 20 + 8 = 328

By regrouping 751 into 7 hundreds, 4 tens, and 11 ones, you can subtract 3 ones from the 11 ones.

Put the missing numbers in each example. Regroup if necessary. Write the remainders.

						Regroup	
		hundreds	tens	ones	hundreds	tens	ones
581	=						
423	=						

673 =
315 =

Write two examples. Solve each one.

Write the remainders for these examples.

962	841	757	472	375
643	514	238	249	149
993	865	736	688	556
728	426	317	239	329

October 25, 1965

Practice in Borrowing

Write the number sentences for these problems in the work space.

1. Roy and John received 227 birthday cards. If 100 of them were sent to John, how many cards did Roy receive?

____

2. Jack and Larry own 316 hens. Jack owns 107 of them. Larry owns __________ hens.

3. Sue and Kay were in the garden. Sue picked 94 flowers and Kay picked 85 flowers. How many more flowers did Sue pick than Kay?

____

4. Mr. Brown had 243 television sets in his warehouse. He sold 127 of them. How many sets remained to be sold?

____

5. Bess had $1.45 when she went to the store. She spent $1.28. Bess had __________ left.

6. The girls in Mary's class had 224 bags of peanuts to sell at a school festival. If they sold 119 bags, how many bags of peanuts remained to be sold?

____

7. Henry picked 44 tomatoes from his garden. He sold 18 of them to Mrs. Jones. Henry had __________ tomatoes left.

October 27, 1965

Regrouping Twice in Addition

157 =	1 hundred	5 tens	7 ones
341 =	3 hundreds	4 tens	1 one
684 =	6 hundreds	8 tens	4 ones
1182 =	10 hundreds	17 tens	12 ones

or

11 hundreds 8 tens 2 ones

or

1100 + 80 + 2 = 1182

You regroup the 12 ones into 1 ten and 2 ones. Add: 17 tens + 1 ten = 18 tens. Regroup the 18 tens into 1 hundred and 8 tens. Add: 10 hundreds + 1 hundred = 11 hundreds.

Write an example. Solve the example.

= hundreds tens ones
____ = hundreds tens ones

Add and check.

476 383 521	243 765 189	113 426 589	301 285 467	200 794 568
215 451 624	231 845 126	365 406 534	470 554 137	617 700 125
820 742 139	800 900 300	293 240 607	405 689 570	520 940 860

October 27, 1965

Addition and Subtraction Problems

Write the number sentences for these problems in the work space.

1. One noon 243 pupils in Eisenhower School went to see the motion pictures shown in the school. There were 398 pupils who did not see the pictures. There were ________ pupils in Eisenhower School in all.

2. The fifth-grade boys of Washington School sold 249 tickets for their school play. The girls sold 315 tickets. The girls and boys sold ________ tickets.

3. Mr. Howe took moving pictures in two national parks on a trip through the West. In one park he used 275 feet of film and in the other 355 feet. How many feet of film did he use?

____

4. During the entire trip Mr. Howe used 580 feet of colored film and 590 feet of black and white film. How many feet of film did Mr. Howe use?

____

5. Mr. Hurff has two steers to sell. One weighs 965 pounds and the other weighs 848 pounds. The two steers weigh ________ pounds.

6. Mr. Berger bought 575 dozen shirts one month and 345 dozen the next month. How many dozen shirts did he buy in two months?

____

October 29, 1965

1.	6.14 -4.09	4.77 -.90	2.53 -1.54	9.62 -6.78
2.	8.56 -7.89	6.57 -6.48	8.68 -8.59	6.81 -6.75
3.	4.68 + 10.05	2.26 + 7.15	1.45 + 7.25	4.86 + 5.63
4.	2.75 8.45 5.96	4.87 9.55 3.07	.08 7.53 .89	8.73 .17 9.10
5.	1.36 -1.27 +4.63	9.45 -9.38 +9.78	34.50 -26.50 +13.98	17.23 -8.29 +8.94
6.	700 -563	500 -258	400 -399	
7.	704 -629	500 -417	800 -72	
8.	-289 362	-482 118	-79 867	
9.	305 - 37	300 - 297	955 - 699	
10.	53 14 22	24¢ 30¢ 25¢	.25 .19 .43	9 + 497 + 298 =

November 1, 1965

Regrouping in Addition

45 = 4 tens 5 ones
37 = 3 tens 7 ones
86 = 8 tens 6 ones
168 = 15 tens 18 ones
or
16 tens + 8 ones
or
160 + 8 = 168

Add the ones.
5 + 7 + 6 = 18.
Add the tens.
4 + 3 + 8 = 15.

Regroup the 18 ones into 1 ten and 8 ones. Add the 1 ten to the 15 tens.

Put the missing numbers in each example. Write the sums. Regroup if necessary.

84 = tens ones
37 = tens ones
25 = tens ones

93 = tens ones
29 = tens ones
36 = tens ones

Write the sums for these examples.

36	35	65	45	44
53	18	80	93	86
24	92	37	76	70

47	80	76	54	66
30	46	92	25	22
65	54	18	87	88

Fill in the missing numerals.

77 + 48 = (70 +) + (40 +)
= +
=

68 + 37 = (+ 8) + (+ 7)
= +
=

November 1, 1965

Problems

Write the number sentences for these problems in the work space.

1. Fred helps his father sell vegetables at his roadside stand. He sold 48 ears of corn on Thursday and 56 ears on Friday. Fred sold ___________ ears of corn in two days.

2. Mr. Wilson sowed wheat in three fields. He sowed 18 bushels in the first field, 26 bushels in the second field, and 43 bushels in the third. How many bushels of wheat did Mr. Wilson sow?

____

3. Alice went to the store for her mother. She bought a bag of sugar for 55 cents and a dozen eggs for 49 cents. Alice paid __________ for the sugar and eggs.

4. Dick joined the Cub Scouts. He paid a fee of 75 cents. He bought a Cub Scout neckerchief for 65 cents and a slide rule for 15 cents. How much did he spend in all?

____

5. The Cub Scout pack to which Dick belongs has four Dens. In his Den there are 9 boys. In another Den there are 7, in another 6, and in another 10. How many boys are in the Cub Scout pack?

____

6. Mr. Jacobs had 59 ducks. He bought 8 more. He then had _______ ducks.

November 3, 1965

United States Money

\$4.54 5.86 \$10.40	In addition, put the dollar sign and cents point in each sum. In subtraction, put the dollar sign and cents point in each remainder.	\$14.35 7.46 \$ 6.89

Add and check.

\$3.56 4.35	\$2.24 8.86	\$6.03 3.67	\$6.85 3.87
\$5.23 2.75 1.64	\$6.32 4.50 3.94	\$7.28 4.63 1.80	\$5.48 7.92 6.09
\$2.41 .38 4.63	\$ .67 9.95 .18	\$5.26 6.58 .08	\$7.90 .85 .38

Subtract and check.

\$7.72 6.49	\$8.48 7.05	\$6.72 3.47	\$9.98 8.74
\$4.95 2.96	\$8.43 2.67	\$5.06 3.28	\$7.54 4.65
\$10.42 8.36	\$8.00 5.42	\$12.45 9.38	\$9.00 6.51

November 3, 1965

Dealing with Money

Write the number sentence for each problem in the work space.

1. Sue had $3.75 in her savings bank. She put $.65 more in her savings bank. Sue has ________ in her savings bank.

2. The fifth grade donated $7.95 to the Junior Red Cross. The fourth grade donated $4.86. How much more did the fifth grade donate than the fourth grade?

____

3. Russell spent 15¢ for a ball, 30¢ for a whistle, and 25¢ for a bell. Russell spent ________ in all.

4. Jerry bought a book for $1.75, some paper for 15¢, and a notebook for 20¢. How much did he spend in all?

____

5. William is saving money to buy a new baseball suit. He saw one that costs $12.95 and one that costs $9.49. William can save ________ by buying the less expensive suit.

6. Terry bought a bicycle tire for $2.49. How much change should Terry receive from a 5-dollar bill?

____

November 5, 1965

Subtract

384 285	294 107	834 287	654 129	302 123
468 279	8500 685	200 34	892 346	

Add

8700 1056	6764 9105	2624 4765	3456 7831	4597 6601
302 204 60 180	701 492 231 387	216 321 105 132	524 130 206 400	353 215 400 604

Find the missing number

61 - 36	11 - 5	42 + 59	+73 100	+65 90	-17 169
44 - 22	65 - 14	+66 80	73 + 80	100 - 99	

Subtract and check.

772 -649	+ ___	848 -705	+ ___	672 -347	+ ___

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